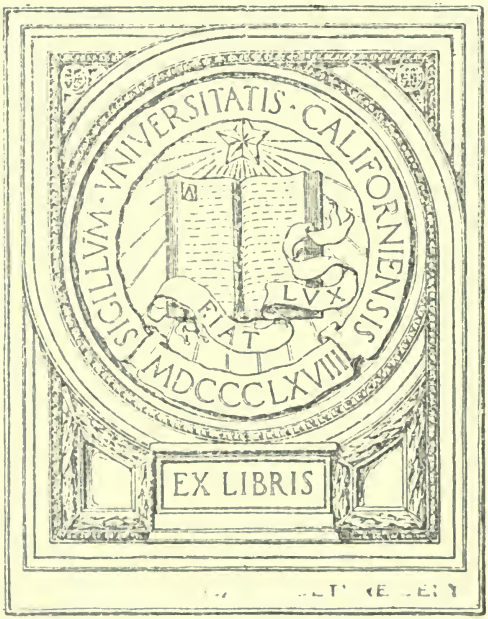
WESTERN AGRICULTURE

J. A. WIDTSOE
EDITOR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PREFACE

Agriculture has won its place in the educational curriculum of our land. It is coming to be well understood that the body of agricultural truth is now so large and comprehensive, and has been so well organized, that it may be used, quite as well as any other science, to impart valuable information and to discipline the mind. Moreover, the feeling is growing that, since agriculture applies, generously, vital facts of many sciences, especially in pointing out man's relationship to nature and society, instruction in agriculture may well be given to all students, irrespective of future life pursuits, as a training for good citizenship. The authors of this book have kept in mind this view of the value and position of agricultural instruction.

This book is a contribution to the proper teaching of agriculture. In the hope that correct facts may be taught in their proper agricultural relation, each chapter has been written by a trained specialist. Further, since the applications of science to agricultural practices must vary according to general climatic conditions, the authors have used more especially the information that characterizes agriculture in the western half of the North American continent. The editors have attempted to unify the style of the different authors and to harmonize the method with sound educational doctrine.

Modern science teaching, and perhaps all teaching, must not depend on textbooks alone. Agriculture is fortunate in having as its laboratory all of God's out-of-doors. The facts presented in this book are supplemented, therefore, with an abundance of directions for practical work. Particular attention is given to the planning of projects, to be used with all good agricultural teaching, but especially, at

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this time, with work conducted under the terms of the Smith-Hughes Act.

The authors and editors are under great obligation to numerous friends, notable among them Dr. E. G. Peterson, President of the Utah Agricultural College, for aid in the making of this book.

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"Green are the waiting fields of toil,
With wild flowers blossoming and sweet,
The living wealth no thief can spoil,
The boundless treasures of the soil,
Poured in profusion at our feet."

Western Agriculture

CHAPTER I

THE LIFE HISTORY OF THE PLANT

The plant has various stages through which it passes from the germination of the dormant seed to maturity. These various stages in any common flowering plant consist of (1) the dormant seed, (2) germination, (3) growth, (4) flowering, and (5) fruiting. The life history of a plant may last but a few weeks or for years and even centuries.

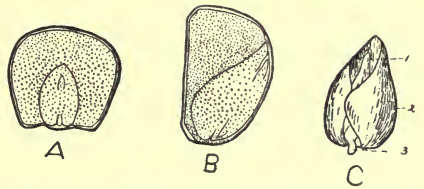

Figure 1.—A, longitudinal section through a corn seed, with embryo lying in endosperm (seen flatwise); B, longitudinal section through seed and embryo (seen in profile); C, embryo removed, showing (1) cotyledon, (2) plumule, (3) hypocotyl. (Lauritzen.)

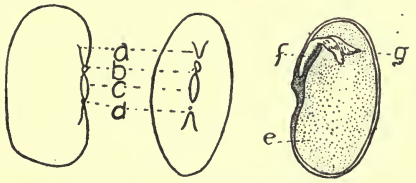

Figure 2.—Bean seed: A, raphe; B, chaiaza; C, hilum; D, micropyle; E, cotyledon; F, hypocotyl; G, plumule. (Lauritzen.)

Structure of Seeds. "The seed is a miniature plant, or embryo, with some accessory parts, in a resting, or dormant, condition and capable, under suitable conditions, of reproducing the kind of plant which bore it." The embryo consists of three parts: (1) the young bud, (2) the seed leaves, or cotyledons, and (3) the young stem. It may constitute all or only a very small part of the seed, depending solely upon the kind of plant from which the seed came. The accessory parts of the seed constitute the seed coats and the

food material enclosed within them and surrounding the embryo. In some instances, however, as already mentioned, all the food material is stored within the cotyledons and in such cases the embryo is enclosed within the seed coats. The accessory parts then serve mainly as protection for the embryo, until it becomes established for itself in the soil.

Composition of Seeds. The food material in seeds, aside from water, commonly belongs to four groups: (1) the carbohydrates, (2) proteins, (3) oils, and (4) mineral matter. The carbohydrates, such substances as sugars and starches, are made up of the elements carbon, hydrogen, and oxygen in various combinations. Proteins are compounds which contain nitrogen in addition to these three elements and sometimes phosphorus and sulphur. Their presence can be detected by adding a small quantity of nitric acid to portions of the tissue and then heating. A pale yellow color appears. Rinse in water, add a little ammonia and a deep orange color will appear. Oils are very complex compounds and are often detected in plants by the use of an acid called osmic acid, which colors them brownish or brownish black. Mineral matter consists of such inorganic substances as iron, sulphur, and phosphorus.

Purpose of Seeds. Seeds serve a triple purpose: (1) continuation, (2) multiplication, and (3) distribution of the plant. They are especially adapted for continuation of the plant from year to year. Being dry, they withstand much better than the green, tender parts all conditions which cause death. Every plant is struggling with every other plant for space, food and light. The more plants of a particular kind in a given locality, the better their chance of success; hence, the value of producing many seeds to insure the gaining of a foothold for continuation and multiplication. Distribution is also closely coupled with these problems. Since a plant is a living, growing thing, food is required to sustain its life and vital activities. The problem of this

food supply is, therefore, rendered less difficult by the dissemination of the seeds to new fields.

Germination. It is very important to remember that, although the seed is dry, the embryo is alive and is in a resting, or dormant, state. With proper conditions at the completion of the rest period, it awakes from its sleep and grows. This awakening and growing is known as germination.

The conditions essential to germination may be properly classified as internal and external. The internal are those which favor within the seed the production of substances called ferments, or enzymes, which change the composition of the insoluble material (the stored-up foods), such as starches, proteins, and oils, into soluble form. The external conditions are suitable temperature and proper amounts of water, together with a plentiful supply of oxygen. Some seeds will germinate immediately after production; others require a resting period before internal conditions permit germination—even though external factors are suitable.

When the conditions for germination are supplied at the proper time, the seed absorbs water and swells. The young plant begins to respire, or breathe, more freely than it has been doing while in the dormant condition; hence the necessity of a plentiful supply of oxygen. During the processes of respiration, oxygen is consumed and carbon dioxide is liberated. The stored foods are made soluble to supply the demands of the growing embryo. Certain changes in form now come about in the young plant.

The miniature stem and bud elongate, pushing their way through the seed coats into the soil. The stem forms roots at its lower extremity. If the portion of the stem above the roots and below the cotyledons continues to elongate, the cotyledons may be lifted or pushed out of the soil. If it does not continue to elongate after the roots are formed, the cotyledons remain buried. One part of the stem elevates the bud into the air where its leaves expand. When these

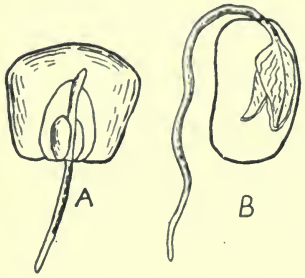

Figure 3.—A, corn seedling, showing manner of germination; B, bean seedling in process of germination.

first true leaves have expanded, the plant is ready to shift for itself and germination is said to be completed.

The Cell. To understand how germination phenomena take place, it is essential to know that the plant is made up of a number of small parts, or units, called cells. If any part of the plant were very highly magnified, these cells would appear as closed boxes or compartments. That which corresponds to the walls of the box is the cell-wall. This encloses a substance called *cytoplasm*, which resembles the white of an egg. Within the cytoplasm lie the heavier nucleus and other bodies known as *plastids*, and surrounding it is a membrane known as the *plasma* membrane. All these parts enclosed by the cell-wall are alive and constitute the only living parts of the plant. The cell-wall is not alive, but is made from the cytoplasm.

Growth. Growth and development of the plant have to do with change of the cells. The cell increases in size and finally divides to form two new cells. These may divide again and again as long as the plant lives. Size depends, then, on the increase in the number of cells as well as their enlargement.

All parts of the plant are not alike. There are the stems, buds, leaves, and roots — different parts known to everyone. Any part, for instance the leaf, examined carefully

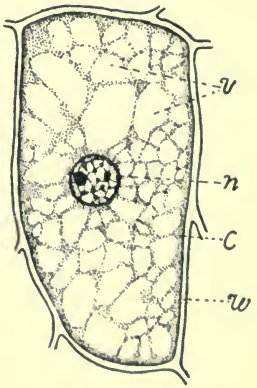

Figure .4—Cell, showing: C, cytoplasm; N, nucleus; V, vaenole; W, cell-wall. (Lauritzen.)

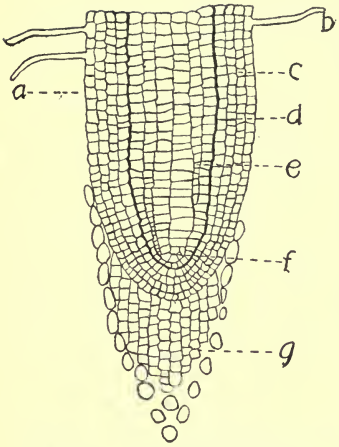

Figure 5.—Longitudinal section of root tip, showing: A, epidermis; B, root hair; C, intermediate layer between epidermis and central cylinder E; D, endodermis; F, growing region; G, rootcap. (Richards.)

under a microscope is seen to consist of cells of various shapes and sizes. Likewise, any part of the stem, bud or root, will show a difference in the form of the cells: Thus, along with growth, which is due to an increase in the number and size of cells, comes a development called *differentiation*, which is due to a change in the shape and in the arrangement of cells according to the work they do.

The production of new cells is limited to rather definite areas in the flowering plant. In the stem, it is limited to the region of the very tip and to a ring between the bark and the wood. In the root, active division occurs just back of the tip, which is called the rootcap. The region of elongation extends beyond the region of active division of cells for some distance. As a result of these growth processes a plant is produced which finally flowers and fruits.

Flowering. The function of a flower is the production of fruit, which contains the seed. Flowers are of various colors and shapes—some gorgeous and showy; others plain and simple. Some are borne singly; others in clusters; but, whatever the difference is, they all have the same function to perform—the production of seed.

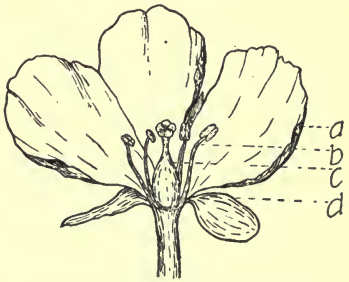

Figure 6.—Diagrammatic section of flower, showing: A, petal; B, stamen; C, pistil; D, sepal. (Richards.)

The organs of the flower are either essential or nonessential. The essential organs consist of *stamens* and *pistils*, which are located in the central part of the flower. The stamen consists of *filament* and *anther*. The anther bears the pollen grains which contain the male sexual cells (male gametes); the pistil consists of *stigma*, *style*, and *ovule sac*. The stigma is the upper part of the pistil, and secretes a sticky substance which causes pollen grains to stick to it. The style is the middle portion. The lower swollen part of the pistil is the ovule sac, which contains the ovules. Within the ovule the female sexual cell is produced in a little sac which is called the embryo sac. It is usually necessary that these male and female cells unite in order to produce the seed. The pollen grain is transferred by some agent to the stigma, where it germinates and grows down through the style into the ovule, carrying the male *gamete* with it. A union between the gametes now takes place. This union of the gametes is known as *fertilization*, while the transfer of pollen to the stigma is known as *pollination*.

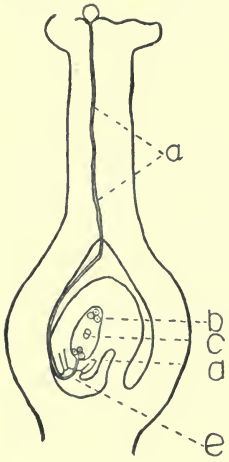

Figure 7.—Diagram of pistil, showing: A, pollen tube growing down through style; B, three antipodal cells in embryo sac; C, fusion nucleus which grows into endosperm; D, egg (center) and two syndergids (helpers) in embryo sac; E, mycropyle. (Lauritzen.)

The nonessential organs of the flower are usually called floral envelopes and are the *corolla* and *calyx*. The latter, which is the outer one, is usually green, while the corolla, the inner, is usually highly colored. These floral envelopes are called nonessential, because they are not necessary to produce a new seed.

Fruiting. After fertilization has taken place, the fertilized cell grows into the embryo. One of the other cells

within the sac, together with the other parts of the young ovule, grows into the accessory parts of the seed and the seed coats. After maturity of the seed, it passes into the dormant condition to await the time when it can spring into renewed activity and produce a plant which may pass through the same stages that have just been described.

The flowering and fruiting stages of some plants occur during the first year; in others, during the second. Still other plants require more than two years in which to produce flowers and fruit. These usually continue to produce seeds year after year before dying.

QUESTIONS

1. What is a seed?
2. Name the parts of a seed.
3. Give the composition of a seed.
4. What purposes do seeds serve?
5. Describe germination.
6. Give conditions favorable to it.
7. Describe a cell.
8. How does growth take place?
9. Describe a flower, stating use and value of each part and of the whole flower.
10. Name and state the principal point in each stage of the life of flowering plants.

EXERCISES AND PROJECTS

1. Secure seeds of corn, peanut, bean, and squash. Note the external appearance of each kind of seed; cut longitudinal sections of the corn; open the two halves of the peanut, bean, and squash. In each case find (a) stored-up food; (b) cotyledons; (c) the young bud; (d) the young root; (e) note the position of the embryo in each case, the location of the stored-up food and the nature of the seed covering.
2. Secure bean or squash seeds. Test them for germination as follows:
   (a) Entirely cover twenty-five seeds with water.
   (b) Partly submerge another twenty-five seeds, keeping the micropyle end above water.
   (c) Using another twenty-five seeds put them on absorbent cotton moistened with water and cover with a plate.
   Note results after two, four and six days.

3. Place three other sets of twenty-five seeds on moist cotton as called for in (c). Put one of these lots at freezing temperature; put another in an oven at 100° C.; and keep the third at ordinary temperature as a check. Note results after two days; four days; six days.
4. Use a pea that has germinated and has a root about an inch long. With India ink mark off spaces of $\frac{1}{16}$ of an inch. Pin to a cork and float in a pan of water. After twenty-four hours, and again after forty-eight hours, note the distance between the marks. Where has growth taken place? Do the same to the stem and find out in what region growth has taken place in the stem.

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CHAPTER II

THE PLANT IN RELATION TO TEMPERATURE AND AIR

The plant, like any other living thing, is influenced by its surroundings. Certain factors directly or indirectly are always at work determining whether the plant shall survive or perish. In considering any one of these factors it must be remembered that others are at work at the same time. The principal factors to be noted now are temperature, wind, and oxygen. Carbon dioxide, water and light will be studied in the following chapters.

Temperature Relation. In passing from tropical to frigid regions, the vegetation also changes, principally as a result of change of temperature. The earth is divided into zones, each of which has vegetation differing from that of any other, but it is not necessary to study the whole world to see the effect of temperature on the plant.

We all know that in the warm days of spring, when the peach tree has finished its winter rest, it starts growth anew and bursts quickly into bloom. Following this warm spring period, a freeze may ensue and the flowers be frozen, causing an entire loss of the peach crop for that year. The same injury often happens to many of the other fruits, such as pears, apples, plums, cherries, strawberries, and raspberries. Every one has seen lucern and potatoes frozen in the fall. Thus slight changes in temperature may affect the plant, determining whether it shall succeed or perish.

Cardinal Temperatures. Critical temperatures recognized for plants are maximum, optimum, and minimum. The maximum and minimum are the highest and lowest temperatures, respectively, at which growth takes place.

The optimum is not so definite as the other two—that is, it embraces a greater range of temperature. It is that temperature at which the plant makes the best growth. Every phase of the plant, such as flowering, fruiting, or germination has its own critical temperatures. They are called *cardinal temperatures.* The following table shows these cardinal points for a number of our common cultivated plants. It is seen that these temperatures often differ.

Table I.—Cardinal Temperatures for Growth

Degrees Fahrenheit*

	Minimum	Optimum	Maximum
Oats	0- 40.6	77- 87.8	98.6-111.2
Rye	0- 40.6	77- 87.8	111.2-122
Wheat	0- 40.6	77- 87.8	87.8- 98.6
Barley	0- 50.6	77- 87.8	87.8- 98.6
Corn	40.6- 50.9	98.6-111.2	111.2-122
Pumpkins	50.9- 60.1	98.6-111.2	111.2-122
Melon	60.1- 65.3	87.8- 96.8	111.2-122
Cucumber	60.1- 65.3	87.8-100.4	111.2-122

*B. M. Duggar, Plant Physiology, Page 403. 1911.

The limits of temperature depend upon the particular kind of plant and the amount of water it contains. The more water in a plant, the more easily affected it is by high or low temperature. The less water in a plant the more resistant it is. To state these facts briefly, we often use the following expression: "Susceptibility to temperature is inversely proportional to the water contained in the plant."

Highest and Lowest Temperatures; Death. Some plants are killed at 113 degrees Fahrenheit, but more can bear heat up to 122 degrees Fahrenheit. There are still other plants that can withstand a temperature near the boiling point of water, as some of the pond scums and bacteria. Even boiling for a short time will not kill some of these. What causes death at high temperature is not definitely known. But the death of a plant by cold may be explained in either of two ways: (1) the freezing is a drying out process; that

is, the water in the cell is withdrawn below that required for growth activity; or (2), the living parts of the cell may be killed on account of the sensitiveness of the protoplasm. This latter reason may account for a plant's dying from cold, although the freezing point has not been reached. Again, other plants may not die until very low temperatures are attained. Some plants flower at 40 degrees below zero.

Bud Protection. Most of us have pulled buds apart. Some are very sticky, because they have a covering of rosin; others are hairy, and nearly all are covered with scales. The rosin, scales, and hairs are provisions of nature for the protection of buds during the winter. They are not a protection from extreme cold so much as from drying and from sudden changes of temperature. These contrivances serve their purposes effectively.

Wind Relations. The wind is a factor which emphasizes greatly all other factors, especially any factor which is working unfavorably. As illustration, it may be noted that in a region already dry, the dry wind increases the dryness by increasing evaporation. When cold conditions prevail, the cold is augmented by cold winds. Plants have greater difficulty, therefore, in withstanding cold in regions in which cold winds prevail. Warm periods are likely to cause injury when they are accompanied by dry winds. On the other hand, free air drainage prevents freezing by moving cold air away. Calm places are called cold pockets.

Wind is sometimes an important hindrance to man, in the dissemination of weeds and obnoxious plants. Wind is, however, valuable to vegetation in bringing new supplies of carbon dioxide to the plant, and in transferring pollen from one part of a plant to another, or from one plant to another. This wind transportation of pollen is an absolute necessity with such plants as corn, box elder, pine, and cedar.

Oxygen Relation. Plants as well as animals require oxygen. While most plants obtain it directly from the air,

a few may obtain it indirectly through the breaking down of substances which contain it. The process dealing with the consumption of oxygen is known as respiration.

Respiration. Respiration in plants and animals is alike, if we exclude the process whereby the oxygen is taken in.

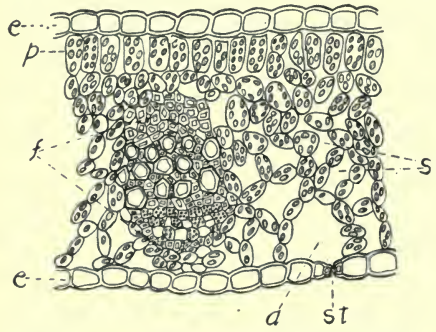

Figure 8.—Cross-section of portion of leaf, showing: A, stem air chamber; E, epidermis; F, fibrovascular bundle; P, palisade cells; S, air spaces; St, stomata. (Richards.)

In plants, air containing oxygen passes in through the stomata and lenticels (special openings through the bark) and then through small spaces between the cells to the places where it is needed. In animals air passes through the respiratory organs, the last of which is the lungs, and through these into the blood, which carries it to the cells in the various tissues of the body. It is to be remembered that it is in the living cells, whether in plant or animal, that the process of respiration takes place. Respiration, in more detail, is a process whereby the consumed oxygen sets up a long, complex series of changes in the substances of a cell. Accompanying these changes, energy is released. This energy causes growth and development and keeps up all those processes accompanying the manifestation of life. Without this energy, the plants are unable to sustain themselves and must die. Wherever respiration occurs, the oxygen of the air is decreased, the carbon dioxide is increased, and heat is released. The thing of fundamental importance, however, is that energy, which is absolutely necessary for the maintenance of life, is released.

QUESTIONS

1. Name the principal factors determining plant growth.
2. Show how temperature affects plants.
3. What temperatures can plants endure?
4. What is death?
5. How are buds protected against cold?
6. How are wind and frost related?
7. What is respiration? Describe it in plants.
8. From where do plants get energy for their life processes?
9. Why is oxygen so important?

EXERCISES AND PROJECTS

1. If a microscope is available, make thin cross-sections of a geranium leaf by cutting with a sharp knife or razor. The leaf is best held between the pieces of a split cork or in paraffin. Mount in a drop of water on a slide and examine under the microscope. Note the small box-like structures. These are cells. Note different shapes of cells. Make an outline drawing and label.
2. After the first frost in the fall take a field trip either to the mountains or the cultivated fields. Note the effect of frost on vegetation. Is it the same on all kinds of plant life? Is the entire plant killed in all cases? If not, why? Observe at least ten kinds of plants and tabulate your observation, giving result of the frost on each plant observed. What is the effect of the frost in different parts of the fields? Can you see any effect from topography of the land? In wet and dry soils? Write in detail the observations you made on this trip.
3. In a field study note what is happening to some of the seeds through the agency of wind. Note the devices on such seeds as the dandelion, milkweed, willow herb, thistle, box elder, etc., which enable the wind to scatter them Report the names of all the plants that you find dependent upon wind for seed dispersal. Make a collection of such seeds.

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CHAPTER III

THE PLANT AND SUNSHINE

Persons of wealth feel they are self-sufficient and independent, but it is easily proved that they are not. The work, genius, and exertion of former generations, often produced with great sacrifice, minister to their comfort. With the modern division of labor, products and services are exchanged and they are indebted to public institutions, such as libraries, schools, and churches. They are thus not only dependent on one another, on society, and former generations, but are, as members of the animal kingdom, dependent on plants either directly by using them as food or indirectly through eating animals, which in turn eat plants. Plants, however, procure their food from dead or mineral matter by means of sunlight. Thus all life is dependent upon the silent work that the leaves of plants are continually carrying on with the aid of sunlight.

Chlorophyll and Photosynthesis. Carbon dioxide, water, and some of the material from the soil that the soil water has dissolved, are used by plants. This solid material must exist in solution in soil, if plants are to grow in it, as explained elsewhere, or else be provided as fertilizer. The water containing this material soaks through the thin walls of the little root hairs and travels up through the trunk, stem, and leaf veins out into the leaves. There is a green substance called *chlorophyll* in nearly all common plants except mushrooms. This green material is in the plant only in the part exposed to sunlight and is formed as the result of the action of light when oxygen and iron are present. It is a tool for making sugar and starches from the carbon dioxide gas that the leaf has obtained from the atmosphere

and from the solution taken up by the roots. Associated with this transformation of carbon dioxide and water into sugar and starch is the storage of large quantities of heat and light energy to be utilized later. The carbon dioxide is consumed and oxygen liberated. This operation is called *photosynthesis*, or carbon assimilation. The leaves are very thin and have a maximum of surface exposed to the sunlight. Photosynthesis is of the greatest importance, since directly or indirectly all plants and animals depend on it for their food supply.

Light Necessary. The light of the interior of ordinary rooms is insufficient for the vigorous growth of most plants. The rate of carbon assimilation increases with the illumination up to a light intensity equal to that of full sunlight.

Sunlight can readily be shown to be composed of many colors by allowing a narrow beam to pass through a glass prism when a colored band resembling the rainbow and called a spectrum will be formed. It has been shown, by growing plants under glass of different colors, that the yellow and orange light are most effective and the blue and violet least effective in making the starches and sugars from carbon dioxide and water. The chlorophyll, of course, helps.

Photosynthesis and Temperature. Some arctic plants can perform this work at temperatures as low as the freezing point of water, but plants of warmer climates require a higher temperature. The rate of photosynthesis usually increases with rise of temperature up to about 77 degrees Fahrenheit (25 degrees Centigrade) after which it decreases.

Transpiration. There are on the leaves thousands of minute openings called *stomata*, that lead into small air chambers, the thin walls of which are kept moist by the juices next to them. An interchange of gases may take place through these walls and also through the openings to the outside. As already mentioned, plants, through their roots, are continually absorbing water, only an insignificant

amount of which is used in photosynthesis. A good deal of it is useful in carrying the soluble plant foods to the growing parts, but there always remains a large part to be thrown off. The process of giving off water from the stomata of plants is called *transpiration*. The air inside the chambers is supplied with water vapor by the evaporation from the moist walls. This moisture escapes through the stomata. The rate is determined by the size of the opening which in turn is regulated by the so-called guard cells that are on the sides of the openings. When plants wilt, because the weather is warm, the air dry, or the wind blowing, the openings become small to prevent loss of too much water. Conversely, they are opened in damp weather and sunlight, if the plant is fresh and vigorous.

Respiration. Plants breathe very much as animals do. In the lungs of animals oxygen is absorbed from the air, and carbon dioxide together with moisture is returned to the air. The same thing happens in the little air chambers mentioned above, the oxygen entering the stomata and then the thin moist wall surrounding the chamber. Carbon dioxide together with moisture is emitted. Plants are found to suffocate without fresh air. During the day much more oxygen is given off as a result of photosynthesis than is used in respiration; hence, oxygen is thrown off in greater excess than carbon dioxide, so that plants are said to purify the air. At night no carbon assimilation takes place; then the respiration depletes the air of its oxygen and tends to make it unfit for animals.

Coal, coke, and graphite are forms of carbon, and wood is about half carbon as shown in its blackening or charring when heated. If these are burned, some oxygen unites with the carbon and forms an invisible gas called carbon dioxide. In this way nearly all the carbon goes up the chimney in the form of gas and is later, when taken in by plants, deposited again in the plant. A plant or an animal will burn almost

completely, leaving but a small amount of ash. This is mineral that was brought up into the plant by the soil water. It is not known just how the process of burning is made to take place at moderate temperature in plants and animals, but it is a fact that slow burning is always going on. This burning is much faster in animals than plants, for animals must not only do work besides performing their normal life processes, but the body of the warm-blooded animal is kept at a fairly constant temperature considerably above that of the surrounding air, throughout the year.

Energy. Fire must have a good draught; so must living things have plenty of oxygen. Living things must have fuel as must the fire. Man and beast become weak and cannot work without food. Like animals, the plants are dependent on the union of oxygen with other substances in their tissues for the energy with which they perform the work of manufacturing their food, and for doing the work of growth, transpiration, and reproduction.

Sun, Source of All Energy. This energy that is used by the animal in living, keeping warm, and working, is stored in the food which comes from the plant. The plant takes the light and heat from the sun and stores them up; therefore, heat and work come ultimately from the sun. Not only so, but every other form of energy that man has at his disposal comes from the sun. Steam engines obtain their energy from the coal composed of plants that were subjected to great pressure without free access of air. The fuel for gas and oil engines comes from the same source. Electric dynamos, if not run by steam engines or gas engines, are run by water power, but the sun raises the water as vapor to the clouds from which it falls as rain. Running down mountain sides, streams communicate motion to machinery that generates the electric power. Thus, all electric power comes from the sun and even the work done by the wind through the windmill is from the same source, since winds

are caused by the unequal heating of the surface of the earth.

Thus we can come back to the beginning and say again that all things and all creatures are mutually dependent. Man is dependent upon his fellows in the social order. Animals are dependent on plants, and plants on sunlight and mineral matter. Truly all life depends on the sun; and, still more briefly, we may say—No light, no life. There was some excuse for primitive peoples' worship of the sun.

QUESTIONS

1. Wherein is man dependent on other men? On nature?
2. What is chlorophyll?
3. Describe its work, showing its importance and its relationship to sunshine.
4. Describe transpiration.
5. How are food manufacture and respiration related?
6. Why must all living things have food?
7. Show wherein the sun is the source of all life.

EXERCISES AND PROJECTS

1. Cover a healthy house plant with black paper in such a way that it is not badly crowded. Fasten the paper at base of stem. Put in a dark room at ordinary temperature. Give it a half cupful of water each day. Examine it in a week; two weeks; three weeks.
2. Put a clean glass jar over a healthy geranium. Be careful not to break many leaves. Note results at end of one or two hours. Explain.
3. Secure a dozen medium-sized potatoes. Sprout by keeping in a warm place for two or three weeks. Some should be sprouted in the dark and some in the light. Explain results.
4. Visit a library to find an illustrated article on famine in some magazine. Why do starving persons become weak and thin?

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CHAPTER IV

THE PLANT AND WATER

Wherever plants thrive, all the conditions necessary to vegetable life are sure to be found. Wherever plants are scarce, entirely absent, or scrawny, something is wrong with the environment. Proper growth is dependent on six favorable conditions: namely, (1) soil as a home for the plant, (2) plant food, (3) light, (4) warmth, (5) air, and (6) water. Besides these, freedom from weeds, insects, and plant diseases is essential. Fertile soil in good tilth supplies a home and plant food, and permits the access of air to roots; climate largely determines how much heat, light, and water plants in any place may have. Of these three, the supply of water alone can be controlled to any great extent by man.

How the Plant Uses Water. More than half the weight of all growing plants is made up of water; some plants consist almost entirely of it. For example, melons contain only 2 per cent of solid substance. Not only green plants, but dried ones, contain considerable moisture. Hay, straw, corn, and wheat contain from 5 to 20 per cent of water. This fact can be detected readily by heating a small quantity of any of these substances in a test tube. The water vapor driven off will collect on the cool part of the tube near the mouth.

Plant food must be dissolved in water before it can be absorbed by the plant. The dissolved minerals are carried upward by water, and, after they have been united with carbon dioxide and water in the leaves, water carries the new plant foods, known as *elaborated* plant food, to all parts of the plant.

Plant Processes and Water. Soil moisture passes into the root hairs when there is a greater concentration of dissolved substance in them than in the soil water. This action is the result of osmotic pressure, a force explained elsewhere in this book (p. 45). When the concentration of any one mineral is less within the root hair than in the soil water, that mineral diffuses inward. Those minerals used for plant food are carried from the root into the stem and leaves, thereby enabling more of them to enter, if there are some at hand in solution. Water, however, goes in only when the total concentration within is greater than the total concentration of the soil moisture; but, as indicated, the minerals behave independently. If the bulb of a thistle tube is filled with a strong salt or sugar solution, a piece of parchment paper or animal bladder tied tightly across the large end, and the whole allowed to stand in fresh water for a few hours, water will rise in the small tube. A force similar to that which pulls water through the membrane causes water to enter the root hair.

Once inside the plant, water moves from cell to cell until a series of small tubes is reached, by means of which it moves toward the leaves, carrying with it the useful materials absorbed by the roots. It is not definitely known what forces cause water to rise to the top of tall trees. When the leaves are reached, however this is accomplished, a part of the water is used in a reaction with carbon dioxide which enters the leaf through small openings called *stomata*. Most of it, though, is evaporated through these openings.

Transpiration, as this giving off of water is called, can be shown by inverting a clean bottle over a healthy house plant. In about an hour water droplets will begin to condense on the bottle. Transpiration also helps to keep the plant cool. If water is not supplied as rapidly as needed, wilting follows on account of a collapse of cells in much the same way that a basket ball collapses as the air escapes.

When the bark is stripped from a plant, a sap-like liquid is found. This is a solution of elaborated plant food being carried downward from the leaves. The woody part just inside the bark is the area in which the water solution is carried upward.

Manufacture of Foods. Green bodies, visible under the microscope, show throughout the leaves and other green parts of the plant. This green substance, known as *chlorophyll*, in some way with the help of sunlight, uses carbon dioxide and water to produce sugar and then starch. Various other substances are formed by the union of these with mineral matter from the soil. These are the elaborated plant foods, which can be used by the plant in increasing its size, and in growing fruit, flower, stem, and root.

Movement of Foods. Water not only carries these new products to various parts of the plant, but moves them again if necessary. Carrots and beets, for example, grow fleshy roots one year, and seed the next, if they receive proper care. The roots become hollow as the seed ripens, on account of the transfer of food material from root to seed. Since such movement can take place only when the substances are in solution, it is clear that water moves the stored food. In much the same way, considerable food is stored in branches and twigs of fruit trees. As the fruit develops, some of this is carried away to assist growth.

Soil Water. Water, held as a film around soil particles, is used more readily, if it is abundant. To maintain a supply of water, farmers irrigate their fields or till the soil to prevent evaporation. Cultivation causes a thin blanket of loose soil to be formed. This *mulch* conserves the water that is in the soil for the use of crops, if weeds are not using it. Since water is desired for the crop, all other causes of loss are reduced as much as possible. Sometimes it is possible to save water not only from one rain to the next but from one year to another. Such water storage makes dry-farming

possible in regions of low rainfall, unless high winds, short seasons or other factors prevent crop growth.

Available Water. All this water, however, can not be used by the plant. Only about half the water that a soil is able to hold without loss through drainage can be absorbed by root hairs. When less than this quantity is in the soil, it clings tightly to the particles. This condition causes slow absorption, and consequently easy wilting. In well-aërated soils, most crops extend some of their roots several feet into the soil. This drawing of water from greater depths increases the supply available to the crop.

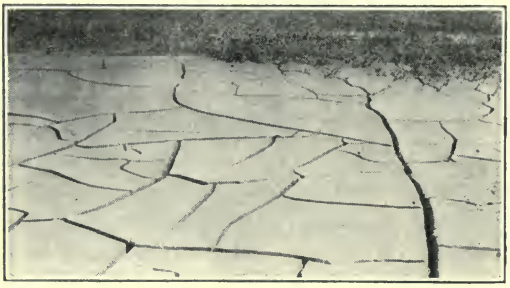

Figure 9.—Effect of too much water. Note the cracks due to puddling of the soil.

On the other hand, soils get overwet when rainfall is heavy or when much irrigation water is supplied, unless it can pass downward easily. Accumulation of water, known as *water-logging*, prevents sufficient air from reaching the roots. Drainage is necessary to get rid of this excess water.

Other injuries sometimes result from alkali salts that water may carry to the surface. These salts may come from deep soil or from higher areas through which excess irrigation water seeps to low spots. The salt-carrying water must be drained off in this case also.

Water Relation. The amount of water present in the soil is highly important in determining which plants can or can not grow on a particular spot. As a result, it is the chief factor in determining a plant community or association.

The term *plant community* is used to designate a large group of plants of one kind or of several kinds growing in a particular locality in response to the same influences, such as in swamps, on hillsides, or on alkali plains. Geographical distributions called zones do not result from water relations so largely as from temperature relations.

Figure 10.—Water relations are shown by brush in wet places and scrubby growth on higher and drier ridges.

Plant Communities. Plant associations in relation to water are usually classified as xerophytes, mesophytes, and hydrophytes. *Xerophytes* are plants, such as the prickly pear and salt-grass, commonly found in regions that are physically or physiologically dry. *Mesophytes* are plants which thrive best neither in very moist nor in very dry conditions. Most of our cultivated crops belong to this group. *Hydrophytes* are plants which naturally live in water or where it can be had in abundance. Algae, watercress, sedges, and rushes are typical hydrophytes.

Conditions Favoring Xerophytic Formations. Xerophytic conditions are due to the nature of the soil and to climate. A dry soil is regarded as either physically dry or physiologically dry. A physically dry soil is one which contains but little water. A soil is physiologically dry,

when, although the water content is considerable, the plant can not make use of it. This condition occurs in soils that are very acid or cold, and in soils which contain considerable alkali. Plants growing in regions of much salt, though called xerophytes, are also conveniently termed *halophytes* to distinguish them from other xerophytes. Soils containing approximately one half of one per cent of salt in solution—along sea coasts and salt marshes, for example—favor this type of xerophytic formation. A low temperature prevents the roots of plants from taking up much water, although it may be in the soil in sufficient quantity to favor growth. Coldness, however, makes the vegetation xerophytic. This condition is manifest in the tundras of the far north, where only a few mosses are able to grow. Other climatic conditions favoring xerophytic growth are dry air, high temperature, and elevation, which hasten the loss of water by transpiration from the plants.

Conditions Favoring Mesophytic Formations. Mesophytes grow on soils that are not especially acid, saline, or cold, and hence not physiologically dry. Likewise they do not thrive on soils that contain so little water as to be physically dry. These types of soils are usually well-aërated, containing a fair amount of plant food and supporting good plant growth. They are illustrated by our cultivated crops, which require a climate not favoring excessive transpiration and in which the temperature is not unusually high.

The conditions favoring hydrophytic formations are the opposite of those listed under xerophytic conditions. The soils are abundantly supplied with water—at times the plants are even submerged. The soils are neither too cold nor too salty, allowing the roots to absorb without much difficulty all the water and food material necessary.

Effects on the Form of the Plant. Plants known as xerophytes adapt themselves to xerophytic conditions in various ways. Some have the leaf surfaces reduced; some

have no leaves at all; still others have their leaves replaced by spines or thorns. The plant, in some instances, tends to reduce its surface by the leaves' becoming more nearly round. It may change in other ways: (1) by producing a waxy covering or an abundant growth of hairs, (2) by forming a thicker outer layer over the epidermis, and (3) the

Figure 11—Vegetation changes markedly from rushes and sedges in the marsh to trees on higher land. (Gage.)

stomatal openings through the epidermis may be lessened in number or occupy more sunken positions. The changes brought about in hydrophytes are the opposite of those in xerophytes. The leaves are larger and thinner with more stomata. The epidermal covering is thin, and often without hair or wax.

Water and Crops. Throughout arid regions, where soils are deep and fertile and where the sun shines most of the days, water is the most important factor in determining how successfully crops can be grown. Until recently no one regarded western farms as worth anything, if there was not water for ample irrigation. Under dry-farming the chief problem is how much water can be saved in the soil. Water is the one thing that limits the production of crops to a greater extent than any other single factor. Soils and sunshine are plentiful; air and warmth abound; only water is scarce.

QUESTIONS

1. Show the relative importance of water to the plant.
2. How much water do green plants contain? Dry plants?
3. Why is water so necessary for plant growth? List its uses in agriculture.
4. What is a mulch? How does it conserve moisture?
5. Why does water enter the plant? How? What causes minerals to pass in?
6. Explain transpiration.
7. What work is done in the roots of plants? In the leaves? In the stem? How does water help in each?
8. In what ways is too much soil water injurious to crops?
9. What should be done with water-logged soils? How?
10. What is meant by a plant community or association?
11. Name and describe three kinds of plants in regard to the supply of water. What are halophytes?
12. How do droughty conditions affect plants?

EXERCISES AND PROJECTS

1. Secure a test tube and burner. Place some dry substances in the bottom of the test tube. Heat gently, keeping mouth of tube cool. Note vapor and drops of water. Explain.
2. Remove the outer layer from a growing plant. Note the solution of plant food.
3. Place in four deep tight pans, cans, or buckets some wet but not saturated soil. Pack the surface gently by pressure with some flat body. To two of these add two or three inches of fine, dry sand or other loose soil. Keep the surfaces dry. Stand all four in a warm but not a hot place. In a week examine carefully. What has happened? Explain. Discuss application.
4. Go for a short trip to study plant communities. Examine all found. Try to explain each. Look for them in distance.
5. Collect leaves and other plant parts showing methods of protection against drying out.

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CHAPTER V

THE PLANT AND THE SOIL

The relationship existing between the plant and the soil is very important. In any system of agriculture, the plant

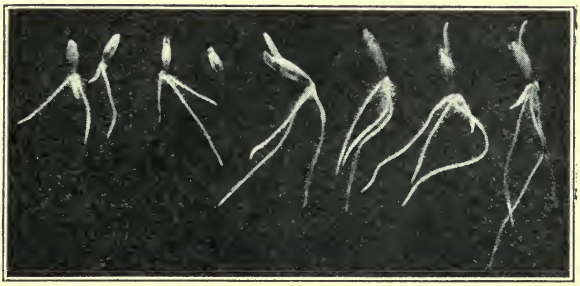

Figure 12.—Small vs. large kernels as to vitality. 4 on right, large oats; 4 on left, small oats.

is dependent upon the soil in a large measure for its food supply, while the soil in turn is dependent upon the plant for the production of the organic matter of the soil, the presence and decay of which are so essential to the maintenance of its productivity.

Seed. Without good seed it is impossible to raise plants economically. The value of the seed depends, among other things, upon the variety grown. Thus, for example, it has been found by the Utah Experiment Station, as a result of seven years' experimental work, that the lowest yielding variety of wheat, Odessa, gave a yield of 20.9 bushels, and the highest yielding variety, Turkey Red, gave 32.7 bushels, making a difference of 11.8 bushels in favor of the better variety of wheat. In addition, the Turkey Red is more valuable for the production of flour, being richer in those

qualities necessary for bread production. Again, the value of the seed depends in a large measure upon its vitality or vigor. The fresher seeds, since they have greater vitality than the older ones, are more desirable. The size of the seed is also an important factor. It has been definitely determined that a better yield may be obtained by planting the larger seed.

Home of the Plant. But good seed alone can not produce crops. There are other essential factors, one of which is the soil, which serves as the home of the plant. The roots of the plant secure a foothold in the soil, thus forming a firm foundation upon which the plant can build its parts above the ground. The home of the plant may vary in texture to great depths; or it may contain a hardpan or a gravelly subsoil at a depth of one to two feet. Although it is practically an impossibility to convert a heavy clay into a sandy soil, much may be done to improve the condition of either extreme type by the addition of organic matter, the thorough tillage of the soil, and the introduction of underdrainage. The structure of a heavy clay soil can, in most cases, be greatly improved by the addition of finely ground limestone in small amounts, or by the addition of sand, although the cost of adding sand in sufficient amounts to modify the physical condition of the clay is probably too great ordinarily to warrant its application. On a limited scale, however, it may be profitable. A few loads of clay, on the other hand, may materially modify a sandy soil.

We are realizing more and more that it is desirable in the case of the home of the animal (including the human being) to have a well-ventilated house which is kept in a sanitary condition. We know that man can not rise to the highest efficiency when he lives in a stuffy, ill-ventilated room. As it is with the home of man, so it must be with the home of the plant. The soil should be kept in a well-ventilated, sanitary condition. Thus, if the home of the plant becomes decidedly

sour, or acidic, the condition may be remedied by the addition of limestone. Fortunately, in the intermountain western section of the country, very few, if any, soils are acidic in nature, being abundantly supplied with limestone. Again, soils that are supplied with an excess of water-soluble salts are rendered nonproductive on account of the accumulation of the so-called alkali. Soils that are water-logged, a condition attributable, largely, in irrigated districts, to the excessive use of irrigation water, are also unsanitary. It is essential, therefore, that the home of the plant be kept in a sweet, sanitary condition.

Source of Plant Food. Besides serving as the home of the plant, the soil furnishes some of its food. The material out of which the plant is made is obtained by it from three sources: (1) from the carbonic acid gas of the atmosphere, (2) from the moisture of the soil, and (3) from the inorganic plant foods, or rock material, of the soil. While the greater part of the plant is obtained from the first two sources, a small, yet essential part is obtained from the rock material of the soil. Thus, if the wheat kernel is burned, about 98 per cent will pass off into the atmosphere, which, in a general way, represents the material obtained by the plant from the moisture and from the atmosphere. The remaining 2 per cent, the so-called ash of the plant, is the solid material obtained by the plant from the soil. In this material there are six of the essential plant foods, without which a plant can not grow normally and reproduce its kind.

Physical Condition of the Soil. The soil should be maintained in the best possible physical condition. By this statement we mean that it should crumble readily when cultivated, and it should have that desirable quality which we speak of as tilth. This is desirable, because a soil in such condition retains moisture well and the plant food contained in it is rendered more easily available to the plant. A soil in a proper state of tilth readily admits the penetration

of the roots of plants in search for moisture and plant food. The physical condition may be changed by proper tillage, by the introduction of organic matter, and in some cases by the addition of the so-called commercial fertilizers.

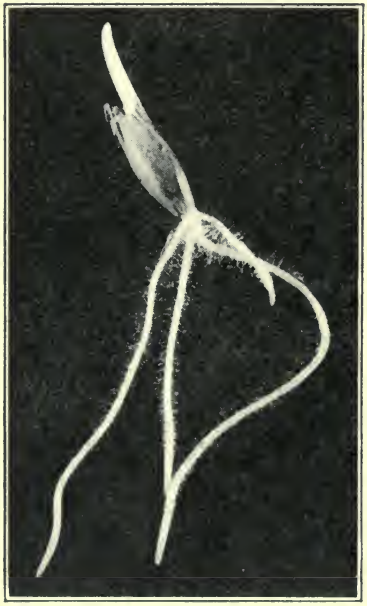

Figure 13.—Kernel of oats enlarged about two diameters, showing root hairs.

Function of Roots. The roots of a plant consist in general of two principal kinds,—the main, or tap, root, together with its different large side roots which serve as an anchorage for the plant, and the small root hairs, which are so small that they will probably escape observation unless a careful examination is made. The purpose of root hairs is to obtain food for the plant. It is essential, therefore, to know the conditions under which a maximum number of these root hairs may be developed. Because a soil well supplied with limestone is both porous and fertile, more root hairs develop than in a soil lacking it.

How a Plant Feeds. If close examination is made of these root hairs, it will be found that there are no small openings in them. How, then, does the plant secure food by means of these organs? The soil solution containing the dissolved plant foods diffuses through the outer covering of these roots hair into the plant sap. The membrane surrounding the root hairs is a semiporous membrane, through which water and certain dissolved salts may pass readily.

Since there is a concentration of water-soluble material in the soil solution surrounding the root hairs, there is a tendency for the water to pass from the soil solution into the plant. A small amount of plant food may be mechanically transported in this way; but, in addition, there is a tendency for a diffusion or a passage of the plant foods themselves from without to within the plant. This process is spoken of as *osmosis*.

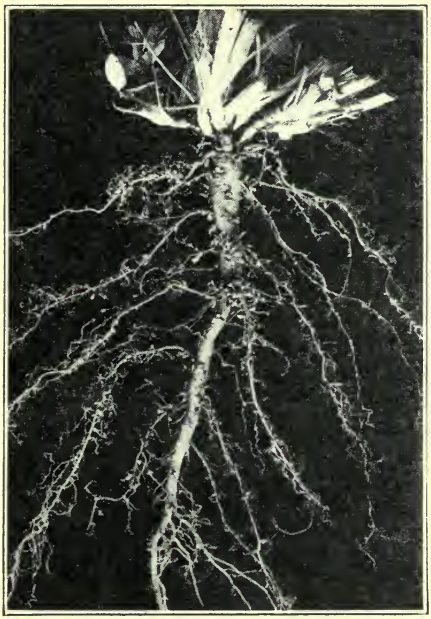

Figure 14.—Nitrogen nodules on clover.

Lime Favorable to Legumes. In addition to the main roots of plants and the root hairs already noted, there are on the roots of certain crops, called legumes, such as alfalfa, clover, peas, and beans, small enlargements known as nodules. These nodules are of great importance in agriculture; for within them are growing, nitrogen-fixing bacteria, small organisms that have the power of utilizing the free nitrogen of the atmosphere and converting it into the combined form for the use of the higher plants. These small plants require a nonacidic soil and consequently develop readily in a limestone soil. Therefore, sour soils must be first treated with limestone before legumes can be grown successfully.

Aëration. It is important that the home of the plant be kept in a well-aërated condition in order that the plant food may be rendered available by different chemical and bacteriological processes. Bacteria, as already noted, play a highly important part in rendering the plant food available.

Figure 15.—Nitrogen tubercles on soy beans.

In order that they may carry on their proper work, an abundant supply of air is necessary. Again, the purely chemical processes of rendering plant food available demand a supply of air; and, in addition, the germination of the seed, essentially a process of combustion, or burning, requires a supply of air.

Temperature. It is important that the home of the plant be kept at as uniform a temperature as possible. Sudden changes are harmful. The temperature of the soil is very difficult to control; but it has been determined that a soil well-supplied with organic matter may be six or eight degrees warmer than a soil not so composed. This fact again points out the necessity and importance of adding organic matter, such as decayed straw, leaves, and barn-

yard manure, to the soil. In addition, a soil that is waterlogged is generally cold and does not warm up readily in the spring, indicating the need of thorough drainage.

Rotation of Crops. It is undesirable to grow any one crop continuously upon the same piece of ground. The crops should be changed regularly and in a systematic manner. Such a change of crops is called *rotation.* As far as practicable the farmer should know definitely the crop that he is going to grow upon any given soil several years in advance of the growing of that crop. There are some well-defined reasons for practicing such a method of farming. By a system of crop rotation, which includes a legume, we are enabled to utilize the atmospheric nitrogen involved in crop production. The rotation also gives us a better method of controlling insect pests and plant diseases. Further, it renders possible the elimination of weeds, and, from an economic point of view, gives the farmer a chance to utilize his time to better advantage by permitting him to arrange his crops in such a way that only one needs attention at one time. Horse labor and irrigation may also be used more economically.

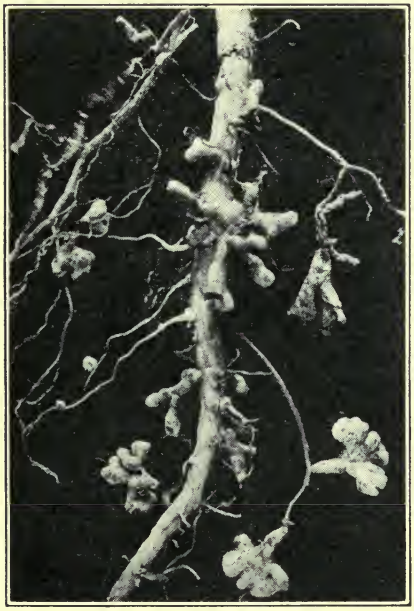

Figure 16.—Nitrogen tubercles on alfalfa enlarged.

QUESTIONS

1. How important for high yield is the variety of a crop?
2. Show how the soil is the home of the plant. How may this home be improved?
3. What is plant food? From where does the plant obtain its mineral supply?
4. When is a soil in good physical condition? How may this condition be obtained?
5. How do plants take in mineral food?
6. Why are soils rich in lime advantageous?
7. In what ways does aëration assist in the activities of the soil?
8. How may soils be made warmer?
9. What are crop rotations?

EXERCISES AND PROJECTS

1. To samples of clay soils add sand, leaf mold, cut straw, and fine manure. Then mix thoroughly with a moderate quantity of water and let stand. Dampen and mix a sample of straight clay. After a few days, when dry, compare results.
2. Add to boiling water all the salt it will dissolve. Cool and fill the bulb of a thistle tube with the solution. Tie a piece of animal bladder or parchment paper over it in such a way as to shut out all air. Stand in a vessel of fresh water. If successful, this experiment illustrates osmosis in from three to twenty-four hours. To be successful, all air must be kept out of the thistle tube.

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CHAPTER VI

MICROSCOPIC PLANTS

Vast as is the number of plants which we see about us daily, still more numerous are those which are about us everywhere but which we do not see because they are so small. These microscopic organisms are bacteria, yeasts, and molds. Bacteria, which comprise the majority of these, are minute, unicellular organisms which multiply by a process called *fission*. They are composed of rod-shaped, spherical, and spiral bodies.

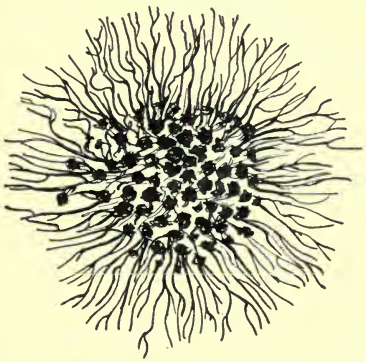

Figure 17—A colony of mold.

Yeasts are unicellular organisms usually considerably larger than bacteria and have a definite organized nucleus. They usually multiply by a process called budding and are oval bodies. Molds are multicellular fungi of considerable size and in types of body are much more complex than either bacteria or yeasts.

They are all classed together as simple undifferentiated plants which never develop roots, stems, or leaves.

The bacteria are of the most importance and are found in large numbers in the air we breathe, in the water and milk we drink, in the soil and on everything with which the soil comes in contact, and on every food exposed to the air. In fact there are very few places where they do not exist. Bacteria are not found normally in the tissues of the plants, nor in the blood and tissues of healthy animals. They are

often present, though in small numbers, deep in the earth and likewise in the sea.

Size. Bacteria are so small that a single grain of dust, too minute to be seen by the unaided eye, may carry large numbers of them. Yet, despite this small size, there is considerable variation in their form and actions,—such a variation that, after careful study of them, scientists have distinguished many hundreds of species and have grouped them in four general families based upon shape, as rod, sphere, spiral, and those whose cells are cylindrical, united in threads or filaments, and surrounded by a sheath.

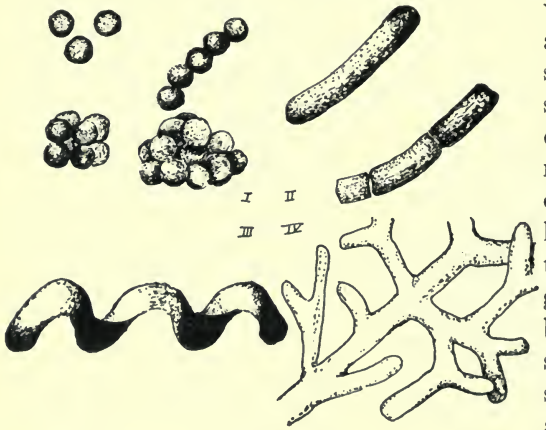

Figure 18.—Bacteria. I. Type of cocci; II. Bacilli; III Spirillum; IV. True branching of one class of bacteria.

The Organism. If we were to examine the individual cell—each organism is a single cell—we should find that it contains a cell-wall, a cell content, or protoplasm, and at least a functional nucleus, although this is not as definite as it is in the higher plants. In addition, the organism may contain small hair-like processes (flagella) projecting from the body, by means of which the cell is able to move through the water or other liquid in which it happens to be. Furthermore, spores are formed by many bacteria, which are simply concentrations of the vital part of the organism in a form especially resistant to heat, light, and other unfavorable conditions. The bacterial cell multiplies rapidly, one cell

becoming two in so short a time as twenty minutes, although the average time is slightly more. With this power of rapid development in mind it is easy to understand such common processes as putrefaction, decay, and souring, which often take place with remarkable rapidity where the life conditions—moisture, temperature, food, and chemical reaction—happen to be exactly right.

Nitrification and Nitrogen-Fixation by Bacteria. Bacteria play an important rôle in the economy of nature. They are essential in plant growth on account of their agency in circulating nitrogen. This circulation of nitrogen is effected by the breaking down of complex compounds which contain nitrogen and by the formation from these of simple nitrates soluble in water and available as plant food. Bacteria have, in addition, the power of drawing the valuable element nitrogen from the air and yielding it up to plants, especially characteristic of legumes, such as alfalfa, peas, and vetch. This process is called nitrogen-fixation and is an extremely valuable process in agricultural practice; for, when these plants or the plant residues are plowed under, it serves to enrich the soil. Still others have the power of growing free in the soil and changing atmospheric nitrogen into organic compounds. Furthermore, many bacteria found in the soil decompose plant residues of the soil and liberate from them essential plant foods.

Industrial Uses. Bacteria, in the process of putrefaction, act on starch and sugar, liberating carbon dioxide. Industrial application is made of bacteria in such processes as tanning and the retting of flax. Bacteria produce, in addition, if properly manipulated, the desired flavors in butter and cheese. These actions are all regulated accurately by inoculating the cream with the desirable organism.

Bacteria and Disease. In contrast with these great benefits which are bestowed on man, bacteria are the cause of various diseases in plants, in animals, and in man. Specific

infections, such as tuberculosis, diphtheria, anthrax, and glanders are caused by bacteria. They also cause inflammation in wounds and abscesses. Furthermore, by decomposition they may produce in certain food products a group of substances called ptomaines, which cause intoxication or even death upon being taken into the animal or human body.

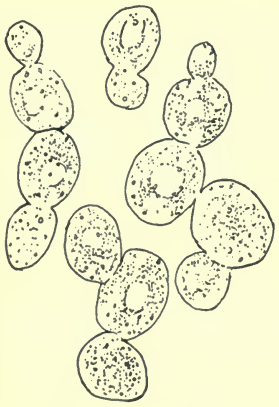

Figure 19.—Yeast.

Yet these very organisms which produce disease are the basis of vaccines and of antitoxins and other substances used in preventing and curing disease. It is an interesting fact that many disease germs call out the latent powers of the body to combat the disease. The utilization of this great agency in fighting and conquering the diseases of man is intensely practical.

Requirements. One of the important considerations in the observation and control of these organisms is their life conditions. They have very definite requirements. Their food must be in such a condition that it can be assimilated; they will not live, except in rare cases, on inorganic matter. The majority will not live unless some nitrogen and mineral salts are present; some require carbohydrates. The waste products of bacteria, which result from multiplication, collect around them and check the growth of the organisms.

Water is necessary in some form for the continuous growth of bacteria. The amount of drying which an organism will stand varies with the species, and varies in the same individual in response to conditions which are little understood. As a rule the vegetative forms do not endure long in the presence of drouth, but spores may resist drying for years.

Bacteria demand, in addition, for their best growth,

a certain temperature, which varies greatly with different species. Some will develop vigorously at 14 degrees Centigrade; others at 40 degrees Centigrade; most, however, demand a medium temperature. Some will develop in the presence of air; others demand the absence of air. We thus have two great groups established: the so-called aërobes and the anaërobes—the former requiring the presence, the latter the absence, of air.

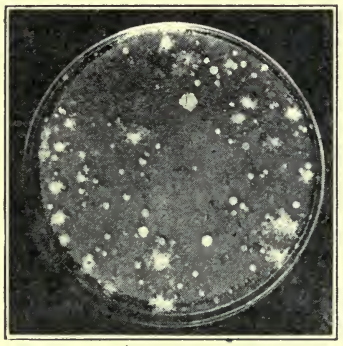

Figure 20.—Culture of bacteria. The white spots are colonies started by the dropping of bacteria on a dish when exposed to air.

Light is also an important factor. Direct sunlight is germicidal; that is, it will kill the organisms if applied continuously. Diffused light is injurious. Electric light is supposed to have the same effect as sunlight. Bacteria thrive best in darkness. The X-ray is known to destroy living tissue on long exposure and bacteria cannot be more resistant. The X-ray is used in the treatment of microbial diseases of the skin.

On account of the necessity of definite conditions which vary with the different species, there have grown up what are called bacterial flora, that is, groups of organisms localized in nature. Thus we have certain organisms normally characteristic of milk, others of water, of soil, and of air.

Bacteria Harnessed. Due to the careful study of these organisms man has reached the point where he may exercise a control over their activity. Many of those which are most beneficial he has learned to utilize to his great good, and many of those that are detrimental he has learned to avoid. Many of the most deadly forms, as previously stated, he has been enabled to overcome by the use of the very

products which the organisms cause to be formed. As our knowledge of this vast invisible kingdom of organisms increases, our ability to control them will increase.

QUESTIONS

1. What are bacteria?
2. How large are they?
3. Describe living bacteria.
4. Of what value are they? Are all kinds useful? Which are injurious?
5. What conditions favor their growth?
6. How are bacteria harnessed?

EXERCISES AND PROJECTS

1. If a microscope is available, soak some moldy hay for two or three days in some lukewarm water. Now transfer a small drop to a slide and add a drop of iodine solution. Cover with clean cover glass and examine under high-power microscope. Note the shape and movement of bacteria.
2. Make up a three per cent sugar solution. Into this put a piece of baker's yeast. Set in a warm place for a few hours and then examine as in Exercise 1.
3. Secure a piece of moldy bread. Place a cover glass gently on the mold. Remove as carefully as possible and place on a glass slide with mold next to slide, being careful not to draw cover glass sidewise. Note the structure of the mold and the manner in which spores are born.

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CHAPTER VII

PLANTS AND ANIMALS

Plants and animals make up the living, or organic, things of nature's realm. Air, water, rocks, and soil are the chief constituents of the inorganic world. Between the inorganic and organic kingdoms there is a wide, and, so far as present knowledge extends, an impassible gulf. Plants and animals possess that distinctive thing called life. Just what life is or where it originated we may never know. Its activities and manifestations, however, are never-ending sources of interest. Things endowed with life are capable of growth and development. They possess the power of combining material from the inorganic world and building themselves up; they also possess the power of reproducing living things, which grow to be like themselves; and in the end they die and disintegrate. Inorganic things possess none of these qualities. A stone may grow larger or smaller as particles are added or taken away, but there is nothing inherent in the stone itself that enables it to do either.

What Plants and Animals Have in Common. Plants and animals possess many things in common. The living substance of each is protoplasm, practically alike in the two groups. Chemically, the greater part of both plants and animals is made up of the same four elements: (1) carbon, (2) hydrogen, (3) oxygen, and (4) nitrogen; and the compounds of these forms are grouped into the same three general classes: carbohydrates, fats, and proteins.

Dependence of Animals on Plants. Animals are, however, entirely dependent upon plants for their food. The plant, out of the carbon dioxide, water, and small amounts of nitrogen and other elements from the soil, builds up and

stores in its tissues complex chemical compounds. Even the nitrogen is nearly all originally obtained from the air, though by the help of lower forms of life it is first stored in the soil. The plant builds up over nine tenths of its entire substance from air and water, and, in turn, builds up the animal's body. Even carnivorous animals obtain their food from plants, as they feed on herbivorous animals.

The plant appropriates from the air carbon dioxide, a gas exhaled by animals and poisonous to them and gives off in its turn oxygen which the animal uses. In the animal body the complex chemical compounds from the plants are either burned to maintain bodily heat or built up into still more complex compounds. In these processes carbon dioxide is given off and returned to the air for the use of plants, thus completing the cycle.

Indestructibility of Matter. Matter is, as we have learned, indestructible. It may change its form, but can be neither created nor destroyed. We may burn a lump of coal until there is nothing left but a trifle of ash, but the carbon has only changed its form, uniting with the oxygen of the air to form carbon dioxide, which passes off as gas. This gas in the air may later be taken up by plants and changed to a still more complex compound. In doing this the plant will take up from the soil minute particles of minerals such as were contained in the ash of the coal. This plant along with others may fall into a marsh and be covered up for a long time, be subjected to pressure, and finally turn to coal to be dug up and burned again.

Limestone, which appears in strata of immense thickness in our mountain chains, owes its origin to the interrelation of minute forms of plant and animal life. The little shell-bearing protozoa flourished in the warmer seas of past geological ages, because they found there an abundance of still smaller forms of plant life upon which they could subsist. Countless billions of these little animals lived

near the surface of the water where the plant life was the most abundant. They extracted the lime from the water to form their calcium carbonate shells, and, as they grew old and died, these tiny shells sank to the bottom. Century after century this process went on, constantly adding to the thickness of the limestone on the ocean floor, until part of the mighty masses we see to-day were formed. From these limestone rocks many of our most fertile soils have been largely derived. These soils in turn produce plants, which are used in turn to feed other animals; and so the continual round of life goes on.

Interdependence of Plants and Animals. No animal can obtain its food directly from the elements or even from the simpler compounds. Without plants to take the elements from the water and soil and build them into compounds, no animal could live. Without animals, fire, or lower organisms to break up these compounds and release the carbon dioxide, the plants would die. We are familiar with this stored-up carbon of plants as the humus of our soils, as peat, and as beds of coal.

Animals and plants are interdependent upon each other in many ways. Higher animals and insects feed on growing plants, often destroying them. Other groups of higher animals and other insects feed on these herbivorous ones and hold them in check, thus restoring such a balance to nature that all may survive.

Pollination of Flowers. Many plants depend upon birds or insects to fertilize their flowers and thus to perpetuate their kind. Clover does not set seed until visited by bumble bees. In some regions there are not enough bumble bees to make it profitable to raise clover seed. In many places the first crop is cut for hay and the second left for seed, because bumble bees are more numerous in the fall of the year. Alfalfa depends to some extent upon honey bees and flies for its pollination. Many varieties of fruit bear better colored and larger crops if cross-fertilized.

Seed Dissemination. The seeds of many plants are distributed by animals. The burdock and the cocklebur are distributed in this way in the winter time. Other seeds, called beggar-ticks, stick-tights, and like names, are distributed in this way during the summer. Birds and animals carry seeds in the mud that clings to their feet. Aquatic birds, especially, carry many seeds in this way from one marsh to another.

Civilization Affected by the Crops. As long as primitive man was content to subsist on what wild animals could furnish him, he needed no home and roved from place to place as circumstances warranted. When, however, he first began to cultivate desirable plants to increase his food supply, it at once became necessary to settle down in one spot and remain there for some time. It was also necessary for him to select that spot with reference to the favorable growth of the particular plants that he cultivated. Thus the great civilized nations of the world have been more or less influenced in their location by the habits of certain plants. The wheat belt of the world is the civilization belt as well, just as much as the corn belt is the hog belt of this country, and for similar reasons. Another type of civilization has followed the rice plant, and still another the breadfruit and the date palm.

How Man Uses Plants. Plants have always furnished shelter for many wild animals and for man. As civilization developed, this primitive shelter under branches developed into rude huts of different structures such as grasses, branches, and bark. Still further development came in the shape of clothing and wooden buildings. Plants also furnish us shade and ornamental trees. They beautify our grounds and appeal to our aesthetic sense by their beautiful foliage and flowers. They contribute not only to our food and shelter, but to our comforts and pleasures as well. Wood enters largely into the construction of tools and vehicles. Wood

and coal furnish our fuel. Wood and other plant structures furnish our paper without which civilization would have been retarded for centuries. Rubber is obtained from plants and adds much to the comforts of to-day. Opium, tobacco, and whiskey are furnished by plants. Plants then contribute to our necessities, our comforts, our virtues, and our vices.

Crops and Live Stock on the Farm. The relation of plants and animals in farm economy is very close. The animal is the best market for much that the farm produces. By feeding farm products directly to animals the cost of transportation and the profits of the transportation companies are eliminated, the middleman's charges and profits are saved, and the farmer, dealing directly with the ultimate consumer, gets the actual value of his products.

The animal acts like a concentrator in mining operations, decreasing the bulk and increasing the value of the product. It also reacts on the crops themselves, as the animal in its growth takes largely from that part of the crop that is derived from the air and water, and leaves much of that taken from the soil in a condition to be returned to the land as manure. It thus increases the fertility of the soil and consequently the productivity of the farm.

The combination of grain and stock raising on the same farm tends also to a more even and economical distribution of labor throughout the year. In grain raising alone much labor is required in harvest time when labor costs highest and is often unobtainable at any price. On the other hand, during nearly half of the year there is no work whatever for the teams and little for the men.

QUESTIONS

1. What is the difference between organic and inorganic matter?
2. What are the fundamental activities of living things?
3. What is the living substance?
4. Could animals live in a region where there were no plants?
5. Which come first—plants or animals?

6. If a lump of coal is burned, could it ever be changed to coal again? How?
7. Can an animal form stone? How? Does a stone ever help to feed an animal?
8. Could plants continue to live without animal life?
9. Why do not animals increase until they destroy all the plants?
10. Are insects of value to plants?
11. Do animals help to distribute plants? Are the plants they distribute of benefit to them?
12. A map of the world showing the wheat belt would also show what other belt?
13. What do plants contribute to the welfare of man?
14. Should a farmer raise both plants and animals? Why?

EXERCISES AND PROJECTS

1. While on a trip, find a rock with lichens on it. Tear these off and examine. Explain what has happened to the rock.
2. Weigh a green plant, then dry it, and weigh again.
   Loss = water.
   Now burn and weigh the ash.
   Loss = organic matter built up from carbon dioxide, nitrogen and water.
   Ash = what was taken from the soil except nitrogen.
3. Go on a trip outside or to a greenhouse. Study flowers to see which ones depend upon insects for fertilization. Note the devices on the flowers to insure insect cross-fertilization.
4. Collect seed from animals, clothing, etc. See if there is any useful plant among them. Study cocklebur, Spanish bayonet, burdock, beggar's-ticks, and other burs. Observe particularly special devices for clinging.

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CHAPTER VIII

THE WEATHER

A farm may be operated according to the most approved methods and yet fail on account of some unexpected change in the weather. A dry spell, with hot winds, in an unirrigated region may wither the grain; a sudden storm may find the grain shocked or hay stacked in the field; hail may knock down the fruit or grain, or a frost kill the vegetables or young fruit blossoms. In most cases, were unfavorable weather known ahead, measures could be taken which would greatly diminish any possible damage. By means of the daily reports of the weather bureau, now so easily accessible, and by some familiarity with local conditions, a person may know what to expect in a general way with reasonable certainty for twenty-four to thirty-six hours ahead. It should be of some interest to know how the staff of the weather bureau is able to forecast the weather, and of some value to be able to use their maps and reports.

Air Pressure. The earth is surrounded by a great ocean of air at least twenty miles deep. This air, like everything else, is attracted by the earth and thus has weight. Because all the overlying layers of air are being drawn toward the earth, they press upon the lower layers and against any surface with which the air is in contact.

A can, about one fifth full of water, corked while it is rapidly boiling, and immediately removed from the source of heat and cooled with cold water poured on the outside will collapse on account of air pressure. A tumbler completely filled with water and having a piece of paper over the top will, when inverted, hold the water, on account of the air pressure against the paper.

The pressure of the gas at a point in the atmosphere depends on how much gas there is above it pressing down, and hence the greater the depth of air, the greater the pressure. For example, the pressure is approximately 8.5 pounds per square inch on Mt. Blanc, 10.5 pounds at Quito, 12.5 at Salt Lake City, and 14.7 pounds to the square inch at the sea level.

Air Cools When It Rises. It is well-known that the tops of high mountains, even under the equator, are always covered with snow. It has been found by the aid of the airship that the higher one ascends the colder it gets, the rate being approximately one degree for every three hundred feet. Pressure has caused varying densities in the atmosphere. The denser the atmosphere is, the more particles of air it contains. As heat is supposed to result from the motion or agitation of molecules, the more molecules there are the more agitation there is and, therefore, the more heat. The rays of the sun in passing through the rarer parts of the atmosphere, therefore, produced little heat and through the lower or denser parts, much more heat.

The neck of a bicycle tire becomes warm while the air is being compressed, or the tire pumped up, and, conversely, it grows cool when the air is let out and allowed to expand. When air rises for any cause it cools very considerably for two reasons. First, it is going into a locality where the conditions are colder, and, secondly, it is expanding because it is going to a locality of diminished pressure. As a result of expansion alone, dry air cools 1 degree F. for every 183 feet of elevation.

Dew and Rain. Water left in the chicken yard or in the water trough will disappear, passing off in the air as invisible, gaseous water. The air always contains some of it, the supply being kept up by the evaporation from lakes and rivers. Whenever the air is sufficiently cooled the water contained in it condenses, forming minute drops. This result

is observed in the formation of dew, causing the dampness of meadows in the early hours of the morning, and in the "sweating" of pitchers or glasses of ice water in the summer, and in the cloud that the breath makes on a cold day.

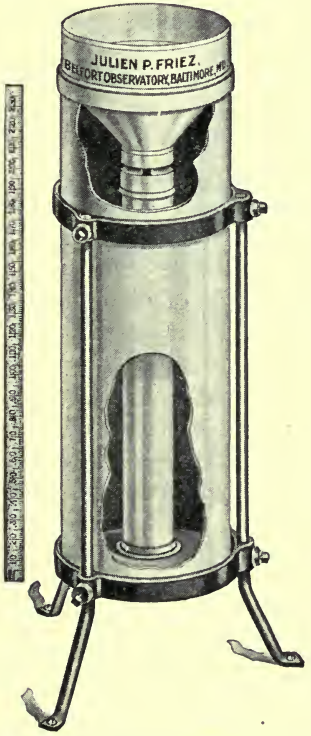

Figure 21.—Standard rain and snow gauge.

The same invisible gaseous water is in the air exhaled in the summer time. When the air is cold this is condensed to a cloud which is nothing more than an aggregate of very small drops of water. The clouds to be observed in the sky are identical in appearance and structure with the one just mentioned and are also formed by the cooling of the moisture-laden air, due either to mixing with colder air or much oftener to rising to higher altitudes. Just as the little particles of dust float around in the air for days on account of the resistance of the air to their fall, before they settle, so these little drops fall very slowly on account of the uprising air current that caused their formation and on account of their smallness. If they cool further, and the drops enlarge, they fall faster, and we say that it rains. When the air is colder than the freezing point, snow or hail result.

Cause of Winds. All points on the earth are not equally heated, but more heat is received at the equator that at points north or south of it; and, at the same latitude, land

gets warmer than the adjoining water even though land and water receive the same amount of heat. The air from the hotter area expands and flows over at the top upon the adjacent air, making the air pressure greater where the extra air is, and less in the section whence it came. Thus, on account of the unequal heating, differences in air-pressure are set up and the air then flows from the points of high to the points of low pressure, causing winds.

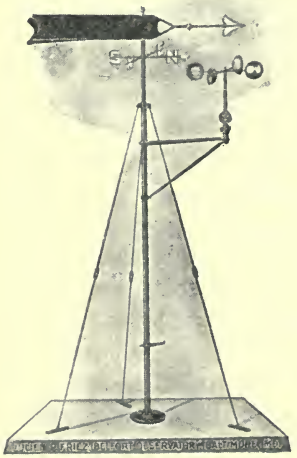

Figure 22.—Anemometer and wind vane.

Weather Observations. Storm and clear weather areas are usually in the form of great circular rotating whirls of air of several hundred miles in diameter. They usually form in the western part of the United States or enter from the Pacific Ocean and travel eastward across the country, often getting nearly to Asia before they break up. Their position is determined as follows:

At the same instant each day and at widely separated stations careful observations of the condition of the weather are made and are exchanged by telegraph. These are represented on maps which are often published in newspapers. They are used by the weather bureau and by others, for making weather forecasts.

Weather Bureau Charts. Curves are drawn through the places that have the same air pressure. At the center of one of the sets of concentric curves "low" is written, meaning that the air pressure is lower there than over the surrounding region. Similarly, "high" is written in another place. From the arrows it is seen that the air is moving outward in all directions from the high and is entering the low from

all sides. Around the high the air is moving spirally outward and downward and in the direction of the movement of the hands of a clock, while around the low the air is coming in, rotating in the opposite direction and rising. Therefore, the low section is the storm area, and the high the fair weather section. Notice on the map that the shaded area which represents the land where it is storming is around the low, while the high is unshaded. On account of this spiral or rotary motion the cold air from the Northwest and the warm air heavily laden with moisture from the South are mixed and then further cooled by the expansion as the mixture rises, causing the precipitation.

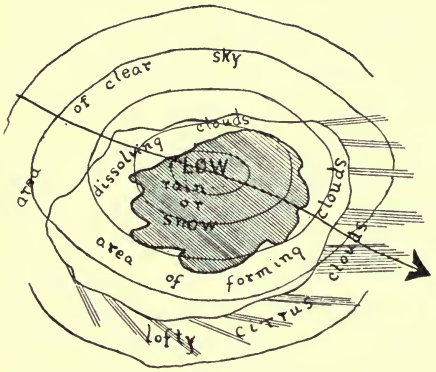

Figure 23.—Showing a storm center.

It is important to get a clear understanding of the difference between the movements of the air in the low and the movement of the low itself, or its translation from place to place. Since these great eddies or storms are carried along by the general easterly movement of the atmosphere in the middle latitudes, the wind must blow into the front of the storm in a direction partly or wholly contrary to the movement of the storm itself. The weather from day to day depends wholly on the movement of these highs and lows.

In the temperate zone they drift toward the East at the usual rate of six hundred miles a day or about twenty-five miles an hour, traveling a little south of East and then a little north of East, ultimately reaching New England.

They may go twice as fast or stop and remain stationary a day or two, much to the embarrassment of the forecaster.

As the storm approaches, fine feathery clouds are to be seen; (notice the chart); later, low rain clouds form and the temperature rises; then comes the rain; finally, as the low passes over, the clouds begin to dissolve and we have clearing weather and falling temperature. Meanwhile, the wind will have reversed direction and the air pressure will have sunk and risen again.

Value of Information. When a high develops in the North and a low in the South and they move off very slowly, we may expect a cold wave, due to the cold north wind; and word is passed to the fruit men. Mariners now receive word by wireless and the flying of signals from lighthouses when a hurricane is approaching. The smaller boats make for the harbor and those in the harbor postpone sailing. The government is also able to predict the flood stage of rivers from the data they collect of the amount of rain falling in the mountains, the slope and penetrability of the ground, and from a study of previous floods.

The farmer, by noticing the predictions of the weather bureau, or, if he has a barometer and observes it, may be fairly well guided in many of his agricultural operations.

Climate. The weather expresses the condition of the air at a definite time—hot or cold, clear or cloudy, dry or wet, calm or windy. One may properly speak of the weather of yesterday but not of the climate; for the climate is the sum of the weather averaged over a long period of time to eliminate irregularities or variation from day to day.

The general characteristic of the climate of the intermountain West is its aridity, the yearly rainfall being but about fifteen inches. Where it is not much less than ten inches grain may be grown by the so-called dry-farming methods, but in the more favored localities not too far from streams irrigation is practiced. On account of the

clearness and dryness of the atmosphere the heat of summer is not nearly as oppressive as in the humid regions, and the daily and yearly range of temperature is large.

Hay, grain, and fruit may be profitably grown in this region, but there is considerable difference in the climate of its different parts and attention should be paid not only to the character of the soil and market, but also to the crops best adapted to the climate and rainfall.

Climate and Man. Dry deserts, the torrid zone, and the polar regions have not proved themselves favorable for the development of civilized man. Here it is too difficult to gain a living. A uniform climate is depressing and produces little development. In a climate that is neither too dry nor too extreme in temperature, habits of industry and thrift, which have brought civilization out of savagery, are made necessary but not too difficult.

QUESTIONS

1. What is a weather bureau? How does it do its work?
2. What do you know about air pressure?
3. What are dew and rain?
4. Explain the cause of winds.
5. How do storms move across the country?
6. What are weather charts?
7. How is man affected by climate?
8. How does weather affect crops?
9. What is "the weather"?

EXERCISES AND PROJECTS

1. Secure weather maps. If these are not available, write for them to the "Local Office, Weather Bureau" in your state capital. Learn how to read them and how to predict weather from them.

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CHAPTER IX

PHYSIOGRAPHIC FORCES OF THE EARTH

All that we know of early geological history is written in the character of the rock that is now exposed on the surface or that has been laid bare by excavations and by landslides or upheavals. A brief knowledge of rock and an interpretation of the geological history of the earth are essential to a clear understanding of our present earth.

Classification of Rocks. Rocks which are formed by vulcanism, that is, those rocks which have been at one time in a molten condition but which are now hard, are classed as *igneous;* the other rocks, which are the hardened materials deposited in the seas, are classed as *sedimentary.* When either of these classes undergoes a change arising from heat and pressure, the rocks are termed *metamorphic.*

The following arrangement gives a brief classification and probably a better understanding of what is meant by these classes:

Table II.—Classification of Rocks.

Igneous	*Sedimentary*	*Metamorphic*
granite	limestone	marble
basalt	sandstone	quartzite
trachite	shale	slate
porphory	conglomerate	gneiss
obsidian		schist
syenite		

Rock Formation. Volcanoes may cause lava flows on the surface or they may force beds of molten rock between other layers. When the top layer is worn off, the igneous rock may be exposed. Granite is so formed; basalt results from surface flows. Sedimentary rocks are formed in two

ways: either (1) by rock particles' or soil grains' being washed into ocean beds and covered to a sufficient depth to be cemented by pressure, or (2) by a concentration of the shells and skeletons of sea animals and dissolved lime in moderately deep water. Limestone is formed by this last method. When limestone is covered and subjected for long ages to pressure by thousands of feet of rock above it, a gradual change converts it into marble. Small quantities of water carrying cementing materials may assist the transformation. Granite is changed to gneiss, sandstone to quartzite, and shale to slate.

Mountain chains are usually preceded by depressions in the crust of the earth. When these depressions are filled with sedimentary rock to the depth of about five or six miles, the pressure causes the lower rock to soften and yield. Since sedimentary rock has less strength than the igneous rock beside it on the rim of the depression, the area of this deposit becomes a line of weakness. Now the earth is shrinking largely from the loss of gases. Because the crust is larger than it needs to be, wrinkling results. Yielding naturally takes place at the weakest point; hence the sedimentary material is raised and is folded or broken with or without great displacements of the broken rock.

Faults. When the sedimentary rock is deposited in a low place that forms an apparent inward curve, and when this is thrown into an outward curve, which is longer than an inward curve, a strain is set up and the sedimentary formation is broken into blocks. Some of the blocks are raised and some lowered, forming a *fault* at the place of breaking. That portion which projects above the surface is known as a fault *scarp,* and this class of faulting is known as a *gravity* fault, or a *normal* fault. When, however, sedimentary rock is forced up by compression, it is either folded or faulted, so that one piece is pushed over the other. This type of folding is known as a *thrust* fault.

It is estimated that by this last method the American continent has been made narrower by more than a hundred miles; that is, if the folded sedimentary rock were spread out in a horizontal position, North America would be a hundred miles wider from ocean to ocean than it is. Some of these folds, as the result of one part's being pushed across the top of the other, are known to overlap more than twelve miles.

Elevation of Ocean Beds. Much rock which was formed deep down in the sea is now, in many places, from one to two miles above the elevation at which it was formed. Evidence is written not only in the character of the rock but in the life of the rock as well. Coral reefs and the remains of numerous other forms of water life are now found as fossils more than a mile above sea level.

Some coasts are gradually rising one or two feet in a century, and others are sinking at about the same rate. When these processes have continued for several centuries, broad patches of sea bottom are brought above water. The Atlantic coastal plain of the southern United States is an example. The old shore was at the western edge of the coastal plain, the so-called "fall line." Much of this area is level and sandy, and the coast line is regular with few indentations. If, on the other hand, the coast is sinking, the water flows into the valleys and causes irregular coast lines having islands, peninsulas, and bays. The Pacific coast of Canada shows this phase of movement. Earthquakes are likely to occur in either rising or sinking regions, especially near the fault lines. The San Francisco and Messina earthquakes occurred on old fault lines.

Volcanoes have caused great changes on the surface of the earth by covering immense areas with lava. Sometimes valleys are filled, as in parts of California and along the Columbia and Snake rivers. At other times cities are covered with lava or ashes, as in the case of Pompeii. Cones

are usually built up around the vent from which the discharge comes, though in some instances the lava passes outward from holes called *fissures* and flows quietly and evenly over a section. In whatever manner the lava issues it gives a new aspect to the area covered. The rock cools and finally weathers into soil that is rich or poor according to its nature and the way in which it decomposes.

Valleys formed wholly by crustal movement are known as *diastrophic* valleys. They are likely to be narrow and steep-sided. These may be formed below the level of the sea or below the level of the regular drainage, and in the early period receive a filling to crowd out the water and thus form the broad level valleys, not a few of which we have at present. Many mountain valleys are of this origin. The more extensive areas, which have been raised up with but little folding or faulting, form the plateau areas.

As soon as one area is raised above the sea, erosion begins. River valleys start to form at the base of the elevated areas. These valleys grow longer and wider, adding to themselves tributaries. They grow deeper as the material is carried away and taken to the lower lands by the water from melting snow and rain.

Streams. As the valley deepens, its deeper parts get into the upper limits of the water table, and the valley has an intermittent stream. When the valley gets still deeper, the stream cuts into or below the water table, and the valley has a permanent stream. The stream cuts faster in regions of softer rock. In such a section, it will develop a broad valley with a flood plain. In this way river valleys are formed.

It is, of course, in this later period that the streams carry great quantities of soil into the ocean to form fertile deltas like those of the Mississippi, the Nile, and the Ganges. Ocean waves gradually move a part of this earth into deeper water. If the coast sinks, it is covered again and again

until depths sufficient to cause rock formation are accumulated. Meanwhile the slow movements of water on the ocean bed are gradually filling the low places, making the ocean bed fairly smooth. This smoothing is due largely to the fact that streams, when they enter bodies of water, lose their power to cut valleys or to transport anything except the finest clay.

Action of Ice. Much of the earth has been subjected at some time to the action of ice. Northern and central Europe, Canada, and northern United States were glaciated. The ice tore off high places and filled low ones. The soils are usually firm and fine except in a district of terminal moraines, which are composed of rock, gravel, and soil mixed indiscriminately. Except for the morainic deposits, these glacial soils are generally fertile, as is shown in the immense harvests of the states of that region. Thousands of lakes in Europe and North America, including the Great Lakes, are the result of the scouring and the damming action of the advancing and retreating ice sheet. Many of the smaller lakes have been filled with sediment, which emptied them by crowding out the water, thereby leaving broad, level tracts of fertile soils, such as those of the Red River area of North Dakota, Minnesota, and Canada. Some of the scoured areas are almost bare. An example of this condition is found in Labrador, parts of which are nearly bare rock. New England soils are also thin in many places.

Other Forces. Underground water constantly dissolves out some rock ingredients and carries them away in solution or deposits them in cracks in the rock as seams of mineral. The white streaks in limestone are slender bodies of redeposited calcite which was dissolved from the lime rock.

Atmospheric agencies—wind, rain, frost, heat and cold, oxygen, and moisture—are constantly weathering away the larger rock masses, tending to reduce all to soil, and thereby to counterbalance rock formation.

Life—both plant and animal—has exercised no small force in the molding of parts of the earth. Some soils are formed almost entirely by former plant life. Coal and oil deposits are caused largely, if not entirely, by plant deposits. In addition, ores such as the carbonates of lead and iron contain much carbon dioxide probably produced by organisms.

The history of the earth has been a series of changes resulting from the combined action of these various forces. Nearly all land areas have been at some time under water, as is shown by the fossils of water animals found in the rocks. Rock, perhaps millions of years old, has been exposed by means of movements in the crust of the earth or by stream action.

Some persons think that the earth cooled from a mass of gas, and that, as it cooled, it gradually assumed its present form and condition. A more recent and an apparently more satisfactory explanation is that small masses were gradually collected by the earth until it reached its present size. The old theory teaches that the moon was thrown off by the earth, but the new one suggests that the moon is a distinctly different body which came within the limits of the attraction of the earth and was held in its present position by the laws of gravity. If we accept the newer teaching, the heat of the interior of the earth should be attributed in part to the gaining of new material and to substances contained rather than as a remnant of an original greater heat that is gradually escaping.

QUESTIONS

1. How are rocks classified? Name some in each of the three groups.
2. How is each kind of rock material formed?
3. Describe faulting. How fast does it take place? Explain the kinds.
4. Discuss the nature and cause of earthquakes.

5. Describe how ocean beds become land. Describe a soil formed in this way.
6. What part have volcanoes taken in forming the surface of the earth?
7. Show the difference between river valleys and diastrophic valleys.
8. How are river valleys formed?
9. How has ice affected parts of the earth? Was this beneficial? Show why.
10. List the great forces that have made our earth what it is.
11. What is known and what is thought of the past history and origin of the earth?

EXERCISES AND PROJECTS

1. Collect various rocks and group them. Learn to know a few of them by sight. What is the value of each for soil?
2. Find diagrams of mountain chains in any geography book. Model your region. Secure clay or putty and make flat mass deep enough for highest mountains. Carve out the valleys.
3. Find diagrams of a fault. Lay down layers of various wet soils. Lift one side until layers break. Note the displacement—that is the fault.
4. Collect pictures of volcanoes and of the effects of volcanic action.

REFERENCES

Any textbook of geology.
Any textbook of physiography.
Any school geography.

CHAPTER X

GEOLOGICAL HISTORY OF THE INTERMOUNTAIN WEST

The great intermountain section of the United States is essentially alike in its geological growth. In general the climate and the soil are alike, in spite of the minor differences that occur. The valleys are similar, though they, of course, vary in size and shape.

Rock. Throughout all the West, the mountains are composed largely of sedimentary rock. In western Utah, most of Nevada, and southern Idaho, limestone is most prevalent, with here and there small areas of sandstone, quartzite, and shale. In eastern Utah, western Colorado, and adjacent Wyoming, shales are common.

This sedimentary formation shows that during the early geological periods this whole western section was a sea or an arm of the ocean. This ocean continued for a long period of time; for, in many places, several thousand feet of limestone are exposed. It is estimated that this limestone probably did not form much faster than one foot in a thousand years. Associated with the limestone is much granite, sandstone, and shale, materials which do not form much more rapidly than limestone.

The great Rocky Mountain chain is also largely sedimentary with granite outcroppings in various sections, notably in parts of Colorado and Montana. Much of Idaho, Oregon, and Washington has been covered with a great basaltic lava sheet.

Land Formation. After the western section had been covered with water for ages there came a time when the section yielded and part of the area was raised above the water.

It began to be weathered by the atmospheric agencies and contributed part of its mass to the rock which was being formed in the water. This deformation did not occur all at once, but continued through a long period. Sometimes a slight lowering set in, so that the area at one time above water was at another time under the water and received an additional deposit.

Mountain Growth in the West. The land which was brought up above the sea formed mountains or plateaus. The first mountains raised in this section were the Rockies, followed by the Uinta Mountains and the Sierra Nevadas. A little later the Wasatch ranges were heaved above the ocean. Inland seas were formed about the islands raised. Some of these inland seas were drained, some were filled up, and others largely evaporated. The reaction which took place in this adjustment of the crust of the earth resulted in the forming of many of the valleys which are in this section. It must not be thought that this movement went on rapidly, for it probably developed no faster than it is going on at present. It is thought by good authority that our mountains are being raised two or three feet a century.

The mountains of the Great Basin are largely block mountains; that is, the thick sediments of the Great Basin were broken into blocks which in the re-adjustment were tipped or tilted so they show the fault along one side, making a steep slope on the fault side and a more gradual one on the other. If a series of layers sloping upward should break, letting one half drop, a deep V-shaped hollow would be formed. The faulted side would be steep. This condition is about what is found in the ranges of Utah, Nevada, and southern Idaho. In the Wasatch fault there was a displacement of about four thousand feet near Salt Lake City. The other displacements were larger or smaller but similar. In the case of the Colorado and Columbia plateaus the uplift was more uniform. On this account the areas are more

nearly flat. The greatest irregularities are due to stream action, which washes out gullies.

Valleys. Because the fault lines run mostly north and south, the mountain ranges tend to run in the same direction. For the same reason most of the valleys are longer from north to south than from east to west. The valleys may be large or small, but are usually of intermediate size.

The useful valleys in the section may all be put into two classes. Valleys like Bear Lake Valley, San Luis Valley, Humboldt Valley, and Salt Lake Valley have been the result of diastrophism, or great earth changes; the valleys of Green River, Snake River, Platte River, and Colorado River have been formed by river erosion.

The useful part of the western area for agricultural purposes is largely confined to the valleys. The character of the soil in the valley largely depends on the character of the rock in the mountains surrounding it. There is little soil in the western area that is being used where it was formed. The soil was disintegrated from the rocks on the highlands and carried to the lowlands. In this way many of the valleys were filled with an alluvial layer rich in plant food.

Alkali. Some of the valleys, however, contain heavy clay soils devoid of organic material but bearing large percentages of alkali salts. One ocean arm shut off by land occupied eastern Utah, western Colorado, and southwestern Wyoming. When the climate became arid, evaporation exceeded the rainfall and the water disappeared as vapor. This evaporation left considerable salt in the beds of the inland seas. When erosion began, the salt was leached into the soils of the bottom of the valleys or washed into lakes of the region. A large part of the mineral in Great Salt Lake came from this source.

Lakes Bonneville and Lahontan. In a later period, after the valleys and mountains of our sections were formed,

climatic conditions so changed as to give a materially increased precipitation which resulted in filling the lower basins with water. This change in climatic conditions resulted in periods of glaciation in the higher altitudes. The waters thus formed contributed to the lakes of Bonneville and Lahontan. During the Bonneville period a thick accumulation was deposited over its area. In these deposits are located the richer valleys of western Utah.

In the case of Bonneville, the water continued to rise until a lake more than a thousand feet deep covered an area of nearly twenty thousand square miles. At this period the lake was tapped from the north at Red Rock pass near Oxford, Idaho, giving it an outlet which continued for a long period of time. The outlet lowered the surface of the lake about 250 feet. The remainder of the lake down to the present Salt Lake has been lost entirely by evaporation. Water marks show the beach lines where the water stood at various levels. The history of Lahontan in Nevada is similar except that it had no outlet.

Lake-formed Soils. During the lake period the washings from the valleys and mountains around contributed largely to the filling of this lake. In many places this filling is hundreds of feet thick. This old lake bed has afforded the richest valleys and the best farming areas in the states of Utah and Nevada and at the same time has formed great areas of desert and worthless country. Benches, or deltas, consisting largely of gravel, lie near the canyons where the still water caused immediate settling. Sandy and loamy material was deposited around the sides of the valleys, forming a middle belt, while clay reached the valley bottoms. The middle belt is much the best farming land, because it is free from alkali and contains little gravel. The benches of the whole West are largely gravel deltas where the streams dropped the heaviest particles when they flowed into the lakes. The valley bottoms, where alkali collects in heavy

soil, are likely to be alkaline or to become so, if higher lands are overirrigated.

QUESTIONS

1. What kinds of rock are most common in the West?
2. What are block mountains? How were they formed?
3. How were mountain valleys formed?
4. What is alkali?
5. Where did it originate?
6. What are the evidences that the Great Basin once held lakes?

EXERCISES AND PROJECTS

1. Look up diagrams of river valleys and diastrophic valleys. Visit some, if near either. Model in clay. Carve out for river valley. Make a fault for diastrophic valley, and then fill in with loose earth.
2. Find diagrams or pictures of waterfalls. Discuss how they are changing the earth. If near one, visit it. If not, make a small model.
3. Collect fossils. Explain what they teach.
4. In clay or sand model out a basin. Pour in water. Agitate gently to make small waves. Observe beach lines. Cause a small stream to run into lake. Note the delta. This shows action of old lakes on the surface of the land.

REFERENCES

Any textbook of geology.
Most textbooks of physiography.
Most school geographies.

CHAPTER XI

SOIL FORMATION

Soils are the earthy material in which plants have their anchorage and from which they obtain their water and part of their food. They are in reality disintergrated rock intimately mixed with varying quantities of decaying plant and animal residues. They are derived from the native rocks by a complex process known as weathering. The agents at work in these processes are changes of temperature, the action of air, water, ice and plant and animal life. These are continually modifying the earth's surface.

Temperature Changes. Probably the greatest factor in soil formation is change of temperature; for, by it huge rocks are torn from their mooring and then broken into fragments. It is a well-known fact that most substances expand when heated and contract when cooled. Now, most rocks are built up of a number of different minerals. These, when heated, expand and contract unequally; hence parts are put under a strain which at times is sufficient to cause cracks of varying size. Throughout the long hot days of summer, the rocks are heated to a comparatively high temperature, as the boy realizes who has chased barefoot over their surface in quest of grasshoppers, butterflies, or wild flowers. At night they are cooled again. This continual heating and cooling gradually causes small crevices to appear in even the most resistant rock. In time these become filled with dust and water. When the cold nights of autumn come, this water freezes. Water, when freezing, expands with a force that is almost irresistible, as broken water pipes each winter bear witness. When the crevices of the rocks are filled with water, the freezing has sufficient force to break

off rock fragments. At times huge rocks break loose and, if on the mountain side, roll into the valley below where they are slowly ground into smaller and smaller particles by various other processes. The speed with which rock weathers varies greatly in different localities, as is shown by the fact that Cleopatra's Needle, the monument brought from Egypt and set up in Central Park, New York, some forty years ago, has suffered much more during the few years that it has stood there than during the centuries it stood in Egypt. In the arid West the wide daily fluctuations of temperature are potent factors in the disintegration of rock and rock material.

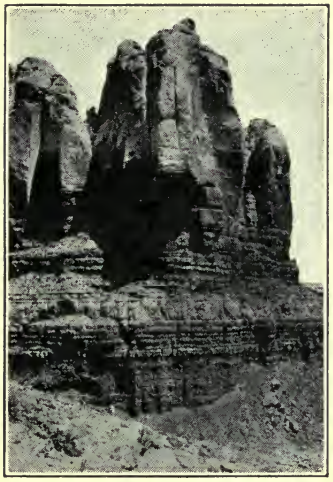

Figure 24.—Changes in temperature gradually wear away the most resistant rock. Near Bluff City, Utah. (After Drs. Cross and Gilbert, U. S. G. S.)

The Atmosphere. After the rocks have been broken into small pieces they become a prey to the atmosphere, which, "when looked at as a whole, has only exceptional calms, usually being in motion either as the gentle breeze, the cyclonic wind, or the restless tornado, but always in motion. These movements do not tamely confine themselves to horizontal paths, but the gases rise and plunge, pursue broad curves and narrow spirals, and would appear, to an eye that could see them from above, a tumult, like the sea in storm. If we add to these mechanical operations the efficient chemical function of the atmosphere, we shall be ready to agree that it is one of the most powerful agencies that helps to mold and fashion the quality of the outer parts of our earth."

Wind. Wind picks up and transports the loose sand and dirt from the high to the low places, ever grinding it finer and finer as it goes. There have been, in Colorado, times when sand drifts a foot high have been piled on a railroad track in half an hour, thirteen carloads of sand being removed from

Figure 25.—The action of wind. White Valley, western Utah.

a single platform on one occasion. The soils of the famous Palouse wheat regions of eastern Washington, eastern Oregon, and northern Idaho, were probably formed in just this manner. The effect of wind is not confined to the transporting of sand from one part of the country to another; but the sharp grains of sand are, while in the air, ground against each other, and blown against the surface of rocks with such force that cliffs are slowly worn away. We often see, in the mountains, places where winds have carved from rock fantastic shapes by the continuous impact of sand. Indeed the sand blast is such an effective agent that it is used to-day in many of the arts where a hard surface is to be ground down.

The effectiveness of this agent is well illustrated in the facts that the telegraph wire along the Trans-Caspian Rail-

way has had to be renewed after eleven years, for the continuous impact of the sand had reduced the wire to one half its original diameter. It is also found necessary to protect by means of piles of rock or short, additional posts the telegraph poles along the Southern Pacific Railway through the San Bernadino pass in southern California, in order to save them from the action of the driving sands. In the humid regions, the soil is protected by a dense growth of vegetation, but in the arid regions the exposed sands are at the mercy of the winds.

Furthermore, the wind often uproots trees which have grown between rocks on mountain sides, tearing off considerable quantities of rock which tumble into the valley below.

Oxidation. Besides the physical actions, the atmosphere has another action known as chemical action. In this the rocks are not only changed in form but in composition. When iron is exposed to a moist atmosphere, it becomes coated with rust and increases in size. When the oxygen of the air gains access to the crevices of the rock, iron and some other constituents slowly oxidize and pass from firm, resistant rock to a loose, noncoherent mass which may be readily acted upon by other forces. The atmosphere also furnishes various acids, which, in connection with water, slowly dissolve parts of the rock.

Solvent Action of Water. Even pure water may be regarded as an almost universal solvent, there being few substances that are not soluble in it to at least a slight extent. When water becomes charged with various substances from the soil and atmosphere, its solvent powers greatly increase, and it exerts a force in soil formation not to be neglected. Water charged with carbon dioxide either from the atmosphere or from the decay of plants and animals, has the power of dissolving various rocks.

Running Water. Looking into a stream of running water, a person can see, at almost any time, grains of sand

and rocks of various sizes sliding and rolling along the bottom of the stream. These grind against one another and against rocks in the bed and banks of the stream, slowly but continually reducing the rocks to particles. The speed with which this result is accomplished varies with the volume of water and the speed of the current.* Large, swift streams are able to carry large rocks and quickly scour out their beds, whereas slow streams may carry sand or only clay. All streams are always transporting some sand, rock, or soil from the higher to the lower levels. Some natural barrier may act as a retainer to the water, causing a lake which acts as a natural settling basin for the water, the rock débris being deposited on the bottom. If this process continues long enough, the lake fills with soil, and the water flows on over the plain only to continue its work of soil formation in some other place.

Lake Bonneville. Many of our western soils are formed under just such conditions. At the time of Lake Bonneville the mountain rivers and small streams poured their waters, loaded with the weatherings of the rock, gravel, sand, silt, and clay from the nearby mountain ranges, into the still waters of the lake. The gravel and coarser material deposited first in the beaches and later the sand and then the silt; the sand and the silt settled farther out in the lake, the clay reaching the middle.

Many of the best agricultural soils of the West were formed in this way, and owe their great depth and great fertility to this method of formation.

Action of Waves. The wind often lashes the water of lakes against their shores, and in so doing rolls rocks up and down their beaches. This action together with the various

*The carrying power of a stream increases proportional to the sixth power of the increase in speed of the stream.—i. e., if a stream doubles its velocity, its power to move earth is not simply doubled but is sixty-four times what it was before.

suspended substances in the surf, slowly wears away the rock. Throughout the Great Basin the history of the extinct lakes may be read by the wearing effect their waters had upon the surrounding mountains. Along all shore lines considerable disintegration takes place.

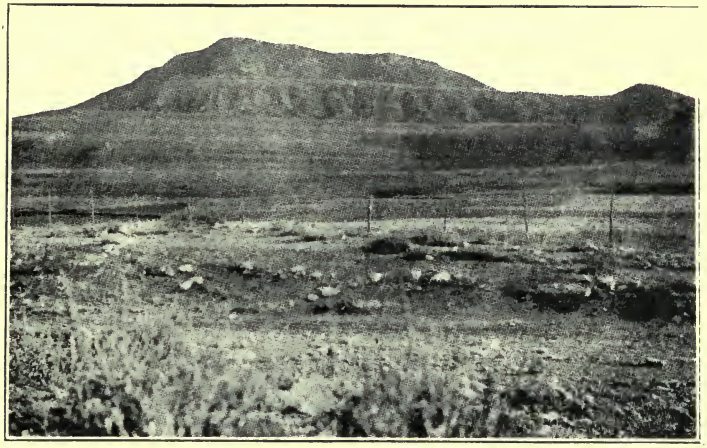

Figure 26.—The action of waves upon rocks. Lake Bonneville marks on mountains three or four miles east of Garfield Beach.

Ice. In the early geological periods, huge sheets of ice covered many parts of North America. These flowed slowly from the highlands into the lowlands. On their downward journey, they froze around huge boulders which they dragged slowly along, grinding one another and the underlying rock into a fine powder. Rocks from the overhanging cliffs were caught up by the surface of the glacier and transported to lower levels. Ice probably took a very insignificant part in the soil formation of the intermountain region, although in other districts it has played a very important one.

Plants as Soil Builders. Even while the rocks are apparrently sound, some are covered with lichens and mosses. These small plants send their roots into the minute crevices

of the rocks and by means of their root acids dissolve their required mineral foods from the rock. The plants die and are replaced by others, their tissues being decomposed by microscopic plants. These bacteria in their activities form acids which attack the rock particles; they also obtain from the atmosphere their required nitrogen; and, when they die and their bodies disintergrate, they add to the rock residues a combined form of the essential element, nitrogen. These are followed by higher plants, which send their roots deep into the crevices; as the roots increase in diameter they force the rocks apart. In this manner plants not only decompose rocks, but they continually add to the soil organic matter which, when partly decayed, is known as *humus*, imparting a black color to the soil.

Animals as Soil Builders. Earthworms, burrowing animals, and the like are continually working over the soil and mixing organic matter with it. These, in some regions, are important factors in soil formation. At times they are present in sufficient numbers in arid soils to interfere materially with the water-holding capacity of the soil, though they are usually of small importance in western soils.

Soil and Native Rock. The native rock is slowly ground into fine sand, which, when thoroughly mixed with organic matter, constitutes the soil. It is thus evident that there is an intimate relationship between the native rocks and the soil resulting from them. In the recent reports of the United States Geological Survey are descriptions of phosphate beds throughout this western section of the country; recently the occurrence of potash deposits has been reported; and our mountains abound in limestone rock. Phosphates and potash carry two of the essential plant foods, and limestone is required in order that the soil remain a good home for the various plants. We should, therefore, expect to find, and do find, large amounts of these substances in western soils, which are largely, therefore, intensely productive.

QUESTIONS

1. What is soil? From what is it made?
2. Name the forces that cause rock-weathering.
3. How does change of temperature disintegrate rock?
4. In what ways does wind wear rock away?
5. How does oxygen affect rock?
6. How does the action of water by solution differ from that of running water?
7. Locate and describe Lakes Lahontan and Bonneville.
8. How were soils affected by these lakes?
9. In what way are plants and animals soil builders?

EXERCISES AND PROJECTS

1. Go for a trip along a stream. Note that the rocks are decaying and that the streams are transporting soil. If possible, learn how the soils were deposited in the present place.
2. Break off a small chip from some soft rock, such as sandstone or limestone, and examine carefully the sides and edges of the same. Place it in a bottle with water and shake violently for a few minutes. Draw off the water and examine the rock. What has taken place?
3. Weigh a quart fruit jar and then fill with very muddy water. Allow the bottle and contents to stand undisturbed over night. If it has not settled during the night, add to it a few cubic centimeters of sulphuric acid (oil of vitriol) or a piece of lime and allow to stand until clear. Decant off the clear water. Dry and weigh the bottle with the sediment. Calculate the percentage of soil in the water.
4. Map the area in which you live, to show kinds of soils.

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CHAPTER XII

SOIL TEXTURE AND STRUCTURE

Soil Types. Soils are variously classified. One classification is: (1) residual soils, (2) colluvial soils, and (3) alluvial soils. Residual soils are formed by the weathering of the parent rock which may be found at varying depths underlying the soil. They are commonly found in high plateaus, such as the Colorado plateau, extending throughout much of southern Utah and western Colorado. Colluvial soils are those which have been moved some distance from their place of formation as a result of rolling downhill or being moved by the action of wind or rain. Alluvial soil is the material deposited from running streams. Soil formed in this way fills the low-lying valleys of the intermountain country, deposited by the mountain streams. The well-formed deltas at the mouths of the mountain canyons are common illustrations.

There are also other ways of classifying soils. For example, they may be classified as (1) sand, (2) sandy loam, (3) loam, (4) clay loam, (5) clay, and (6) peat, depending upon the physical composition of the soil, i. e., the arrangement and varying quantities of the several sizes and kinds of particles.

Soil Texture. The arrangement of these soil particles in the soil in varying quantities gives rise to the several kinds of soil as indicated above. The term soil texture refers to the soil type. Just as we speak of cloth as having a fine or coarse texture, so we may speak of soil as having fine or coarse texture, depending upon the size of the individual grains. The texture of the soil particles depends upon the

varying quantities of sand, silt, and clay in the soil as indicated below in Tables III and IV.

In the Juab county soil there are a greater number of the smaller grains, such as clay, and fine and medium silt, which compose a somewhat compact clay loam. With the

Table III.—Juab County Farm.

Depth in feet	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Medium sand	8.93	8.99	8.73	11.36	15.69	8.93	16.28	12.60	23.57	15.48
Fine sand...	20.05	16.48	12.38	18.87	19.48	27.40	25.00	22.52	26.09	21.45
Coarse silt...	21.97	19.95	22.53	19.06	23.88	22.27	21.88	21.91	19.25	18.63
Medium silt.	15.23	16.78	17.53	17.25	15.43	13.51	13.73	17.03	10.04	15.77
Fine silt.....	13.25	14.88	14.47	8.93	8.01	7.11	8.68	9.74	6.56	11.71
Fine clay....	15.73	16.68	18.62	20.68	12.41	10.03	12.19	13.29	20.95	13.36

Table IV.—San Juan County Farm.

Depth in feet	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Medium sand	11.07	13.54	12.45	13.80	.....	13.31	18.34	9.57	10.19	.....
Fine sand...	50.21	45.21	46.10	45.38	.....	32.39	36.43	40.48	42.29	.....
Coarse silt...	12.80	11.40	16.78	13.58	.....	16.50	13.87	16.55	15.71	.....
Medium silt.	8.18	7.94	9.22	9.72	.....	14.37	19.03	9.46	8.55	.....
Fine silt.....	5.47	6.27	5.26	5.51	.....	9.14	9.19	7.39	6.41	.....
Fine clay....	9.77	11.10	5.64	9.92	.....	12.02	14.94	12.33	13.84	.....

San Juan county soil, on the other hand, there is a greater number of the medium and fine sand particles, composing a coarse-grained, sandy soil. The latter soil is easier to cultivate; the plow enters the soil easily and scours readily. As the soil becomes heavier, i. e., contains a greater number of the finer particles, great care must be taken to prepare the seed bed when the soil is in the proper condition—when it is neither too wet nor too dry. The farmer speaks of the sandy soil as a *light* soil, while clay is called a *heavy* soil, although sand weighs more than clay.

The texture of a given soil depends in a large measure upon the parent rock out of which the soil was originally formed. The weathering of sandstone results in a sandy soil of coarse

texture. The weathering of shale, on the other hand, makes a heavy clay soil of fine texture. In the arid West many of the soils are derived from the intermixture of several kinds of weathered rock, producing soils of all degrees of texture.

Soil Structure. The soil must be well supplied with

Figure 27.—Good deep soil.

plant food, but this fact does not relieve the farmer of the necessity of getting his soil into proper physical condition which greatly influences the temperature of the soil, the food supply, the penetration of the plant roots, and the circulation of soil air necessary to the bacterial life of the soil. This physical condition is *structure;* it has nothing to do with the size of the particles.

How to Modify Soil Structures. The rock particles in the soil are still subject to the same weathering influences by which they were formed and are by them being continually changed in texture to a slight extent. The farmer has little control over the texture of the soil. Sandy soil remains sandy; clay soil remains clay. Much, however, may

be done to modify the structure so as to increase its crop-producing power. The structure may be modified by plowing or cultivating at the proper time. If the soil is plowed or cultivated when too wet, the heavier clay soil has a

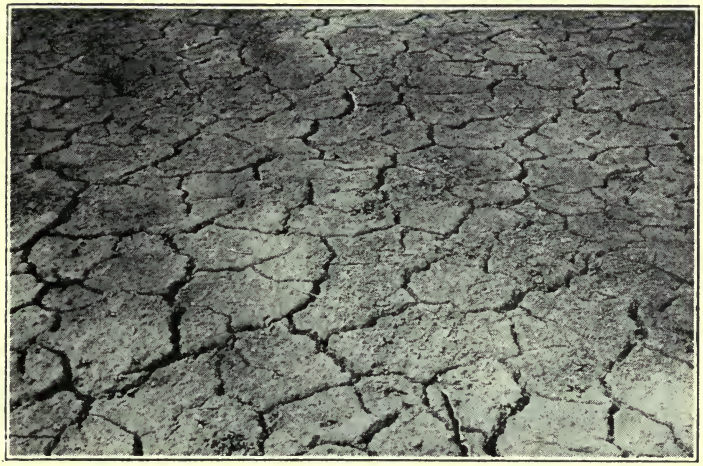

Figure 28.—This picture was taken a few days after a heavy rain, previous to which there had been thorough cultivation. Note the baking and cracks resulting from a lack of proper physical condition.

tendency to puddle, or break into a hard impervious mass unsuited for crop production.

Fall plowing gives the weathering agencies, such as frost and water, a better chance to penetrate the soil and thus render possible the preparation of a good seed bed. The presence of water-soluble salts also materially modifies the structure of the soil. Thus it is somewhat common in the arid West to have very coarse-textured soil, similar to sand, consisting mostly of limestone particles cemented together by the water-soluble salts. Some of the alkali salts, such as sodium carbonate, or black alkali, cause the soil particles to run together, forming a hard, impervious mass which can best be destroyed by the addition of gypsum.

An acid soil may be improved by the addition of ordinary limestone. Many soils have a tendency to run together when deficient in organic matter. This fault may be remedied by addition of barnyard manure or by plowing under of plant residues or green manure. The soil texture may be modified by thorough, continued cultivation, such as is carried on in the production of the mulch in dry-farming operations.

Figure 29.—Soil and subsoil.

Baking of Soils. Some soils, on account of a deficiency in organic matter and limestone, have a tendency to bake, i.e., become hard and compact. Although our arid soils are not rich in organic matter, they are exceptionally rich in limestone and, as a result, baking of soils is not common with them. Black alkali soils have a tendency to bake, but this may be readily overcome by the addition of gypsum. If the baking of a soil is caused by the absence of humus, provision should be made for the addition of barnyard manure or for the plowing under of green manure, such as a crop of alfalfa, clover, or cowpeas.

Soil and Subsoil. In a humid section the native plant roots penetrate into the soil to a uniform depth of twenty to

twenty-four inches, and, when they decay, there is a characteristic change in color below this point. The under part is called *subsoil.* The surface soil is dark colored, while the subsoil is light in color. No such change in color is noticed in soils of the arid region, because our native plant roots penetrate to much greater depths. This penetration of the plant roots is made necessary by their search for moisture and possible by the almost uniform texture and structure of the arid soils to considerable depth, as indicated in the above table. This uniformity renders possible deeper plowing in the arid region than in a humid section where the turning up of the subsoil renders the soil nonproductive.

Figure 30.—Root system of alsike clover plant, showing immense growth of roots which are so beneficial in enrichment of soil by the clover crop.

Influence of Moisture Content. The moisture content of the soil is frequently the limiting factor of crop production in the arid regions. The amount of water retained in the soil is dependent in a large degree upon the soil texture. A fine-textured soil is capable of retaining more moisture than is a coarse-textured one, on account of the greater surface exposure; but a soil of too fine texture is not desirable, since the circulation of the soil air and the free penetration of the plant roots would be impeded.

Productivity of the Soil. The proper physical condition of the soil is of prime importance. It is essential to have a soil rich in plant food, but this alone will not insure crops. A soil having the proper physical condition holds more moisture and is better able to receive and to give it up to plants. Such a soil is suitable to the important bacterial processes that convert the plant food into a condition suitable for assimilation by plants. It permits the free circulation of the soil air and thus assists in putting the soil, the home of the plant, into a better sanitary condition.

QUESTIONS

1. Classify soils.
2. What is a soil type? Name the types.
3. What is soil texture? Texture?
4. How may they be modified?
5. How may baking be controlled?
6. What is subsoil? State its importance.
7. What makes a soil fertile?

EXERCISES AND PROJECTS

1. Collect various kinds of soil. Put in bottles, label and preserve.
2. Wet some heavy soil—clay or clay loam. To some add fine manure; to some, lime; to some, sand; and to some, nothing. Set to dry. Note results.

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CHAPTER XIII

PLANT FOOD IN SOILS

Food Supply. The physical condition of the soil is of great importance in crop production; but it must not be forgotten that the plant, like the animal, must be furnished with a food supply. The animal needs not only sufficient food, but a variety of food in order that it may thrive. Likewise, there are certain substances which all plants must have in order that they may grow normally and reproduce their kind. The plant secures its foods from three sources: (1) the water, (2) the air, and (3) the soil. Most plants are largely water, from 70 to 90 per cent. Thus 76 per cent of the sugar beet is water, and 4.75 per cent is ash, the remainder consisting of carbohydrates and nitrogenous matter. In a consideration of the plant food, it must be kept clearly in mind that there are ten elements which are absolutely essential to plant growth. These substances are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, iron, and sulphur.

Carbon is an essential substance in all organic matter. Starch, for example, which is a common vegetable product, contains 44 per cent of carbon, which is obtained by the plant through its leaves from the air. When food is eaten by animals, this carbon is used in the various animal processes, and one of its decomposition products is carbonic acid gas, which is thrown off by the animal into the atmosphere. This substance is of no use to animals, but is of very great importance to the plant, which utilizes it in building up much of its tissue. The conversion of the carbonic acid gas into the compounds which are found in the plant takes place in its leaves in the presence of the green

coloring matter of the leaf, the so-called leaf-green, or chlorophyll. It is also necessary that a certain amount of heat and light be furnished in order that this process of fixation of carbon may take place. This process is spoken of as photosynthesis.

Hydrogen and Oxygen. Water is composed of two elements, hydrogen and oxygen. As we have already noted, from 70 to 90 per cent of the plant consists of water. These two elements, therefore, in combination, serve as a very important part of the food of plants; but, in addition to their use in the form of water, they also serve other highly important functions. Hydrogen and oxygen, for example, are necessary in the formation of starch and other plant products. Starch consists of 44 per cent of carbon, the other 56 per cent being hydrogen and oxygen. The hydrogen in the starch, of course, comes originally from the water. Oxygen may be obtained by the plant either from the atmosphere or from water. Hydrogen and oxygen are important also in the formation of many other plant organs and products.

Nitrogen is also an essential plant food. It forms a part of protoplasm which is found in all living matter. Without nitrogen there could be no life of any kind. This important plant food is deficient in many of our soils. It is absorbed by the plant through the roots from the soil in the form of combined nitrogen, principally as nitrates. The conditions in the soil that are favorable to the production of these nitrates are, therefore, very important. The lack of nitrogen in the soil results in a reduction of the leaf surface of the plant and in a stunting of the stem growth. It results in the early flowering of the plant and an attempt to reproduce seed, in much the same way that a deficiency of water would act upon the plant. An excessive amount of nitrogen results in a weakened condition of the plant and renders it less resistant to the inroads of plant diseases and insect pests.

Phosphorus, another important food element, is found in all living matter. Without it, new cells cannot be produced. Therefore, growth cannot take place in the absence of this substance. In addition, it seems that phosphorus is necessary for the production of leaf-green, or chlorophyll, the presence of which is so necessary for the proper utilization of the carbon as a food of the plant. In the absence of phosphorus, neither sugar nor starch is formed in the leaf of the plant, growth ceases, and the leaves turn yellow. It is used by all plants in large quantities and has a tendency to concentrate in the seeds of plants, the more salable products of the farm. Phosphorus is very deficient in most of our soils; hence, with injudicious methods of farming, there is a tendency to exhaust this plant food by selling it as grain from the farm. The farmer should, therefore, consider means of conserving this element. Phosphorus is the limiting factor of crop production in many soils in America.

Calcium. In the absence of calcium, there is the failure of the normal production of leaf-green, or chlorophyll; the leaves turn yellow and starch is not converted into sugar. It seems that the ferments which cause this conversion into sugar are not produced in the absence of calcium. In addition, calcium probably plays a very important part in the neutralization of acids in the plant juices. It is essential for the production of the nucleus and the chlorophyll bodies.

Many soils are deficient in calcium, and, as a result, are acidic, or sour. Before they can be raised to normal productivity, such soils must be corrected with limestone, which is the cheapest form in which calcium may be obtained. It is of special importance in the soil, since it favors the process called nitrification, that is, the process by which nitrates are produced in the soil. These nitrates, as we have seen, are needed to furnish the plant with its supply of nitrogen.

Magnesium. The plant seems to develop normally in the absence of magnesium until it attempts to produce seeds;

but, if magnesium is then absent, the flowers may not form, or, if they do form, the fruit is not set. Thus, a very small amount may be all that is necessary until the time of flowering, when large demands are made for this substance. Although magnesium is an essential plant food, if it be present in the soil in too large quantities, especially in the absence of calcium, it acts as a poison. Calcium seems to offset this poisonous action of magnesium. In addition, it occurs in some soils in the form of magnesium sulphate (Epsom salts), a water-soluble substance, and as such is one of the more common alkalies.

Potassium, or potash, is a substance which occurs in the ash of plants in large quantities. The pioneers of the intermountain West made use of the ash of plants in their soap making, the potassium occurring in the ash in such large quantities that it could be leached out for this purpose. It is demanded by all plants in large quantities and especially by such plants as the sugar beet. In the absence of potassium, there is a cessation of growth. The plants seem to have a normal green color, but no starch or nitrogenous material is formed. Potassium, therefore, seems to play some part in the formation of starch, sugars, and nitrogenous compounds. The presence of potassium in the plant also seems to hasten and perfect its maturing and to assist it in a better utilization of moisture, which, as we know, is the limiting factor of crop production in the West. Potassium in the soil seems to help also in the retaining of moisture. Clay loams are usually rich in this element.

Iron, though demanded by all plants in very small amounts, is essential in some way in the production of leaf-green, although not present in this compound. In the absence of iron, leaf-green is not produced. The red coloring matter of blood contains iron. It occurs in the soil in such large quantities and is utilized by all plants in such small amounts that its supply will never become exhausted.

Sulphur occurs as an essential constituent of many of the plant compounds. In some of its combinations it gives to such substances as onions and garlic their characteristic odor and taste. It is present in horse-radish and mustard oils, and is an essential constituent of some of the more important nitrogenous compounds found in plants.

It is thus seen that plants, like animals, need food, and, like animals, they need a variety of food in order that they may thrive and reproduce a good yield of their kind. As Löew has aptly said, "Every plant absolutely requires a certain minimum of each mineral nutrient, and, in most cases, besides this minimum, it takes up not only an excess of these various compounds, but also substances which are perhaps useful but not absolutely necessary for plant functions, such as sodium and silica."

Summary. The plant foods may be divided into three classes depending upon their relative abundance and economic value. The first class consists of carbon, hydrogen, and oxygen. The carbon supply in the air is automatically maintained by the carbonic acid gas thrown off from the lungs of animals. Hydrogen and oxygen are obtained by the plant from the water of the soil, which is maintained in our soils by the rain and snow and is returned to the soil by the principles of dry-farming and by the application of irrigation water.

The second group includes calcium, magnesium, iron and sulphur, which are used by all plants in such small quantities and of which so much exists in our soils that their supply will never become consumed, consequently they are rarely, if ever, added to the soil as plant foods.

The third group consists of nitrogen, phosphorus, and potassium which are used by all plants in large quantities, and which exist so scantily in the soil that they may be easily exhausted. These substances, therefore, have great economic value; they are the essential constituents of the

commercial fertilizers placed upon the market. The American farmers spend about $100,000,000 annually for the purchase of these three plant foods.

QUESTIONS

1. Name the sources of plant food.
2. Name the elements essential to plant growth.
3. State the use of each in the plant.
4. Give the approximate proportion of each found in plants.
5. Which of these are most likely to be lacking?
6. How may these deficiencies be made good?

EXERCISES AND PROJECTS

1. Place a piece of filter paper in a large funnel. On this place a double handful of soil. Pour about a quart of water over this slowly in such a way as to wet the soil thoroughly. Catch what water passes through. Evaporate this. Explain results.
2. Place a single handful of loam soil in porcelain or metal vessel. Heat strongly until the soil "burns." Explain.

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CHAPTER XIV

FERTILE SOILS

Factors of Crop Production. In the consideration of soil fertility it should be kept in mind that there are six positive factors of crop production: (1) the seed, (2) the home of the plant, (3) heat, (4) light, (5) moisture, and (6) plant food. For best results no one of these six factors can be ignored. Each one is equally important. Some of them, however, are under better control of the farmer than others. Thus, the farmer has very little control over the light factor. Fortunately, however, the amount of light falling upon an acre of soil is sufficient for the production of many times the average yield of crops now obtained. The heat factor may be controlled to a certain extent by the farmer in securing a proper structure of his soil through the addition of organic matter, and by underdrainage. The home of the plant may also be kept in a more sanitary condition by the use of limestone and proper cultivation. Considerable has been done in recent years in the selection of better seed. In the arid West it is important that the soil moisture be conserved through the practice of the principles of dry-farming and irrigation. In the irrigated districts the moisture factor is under better control than in the humid districts. The last, or food factor, is the one that is under best control.

Virgin Soils Fertile. A virgin soil when first turned by the plow is in a state of high fertility, that is, its crop-producing power for cultivated crops is at a maximum. Since such a soil has been producing native crops for indefinite periods of time, why is it that its power to produce cultivated crops gradually decreases? As soon as the soil is formed by the weathering of the rock particles, microscopic

plants begin to grow upon the rock powder. These microscopic plants gradually give way to plants of a higher order. When the plants decay, their remains are added to the soil, and are incorporated with it. This process results in the production of a soil containing organic, or vegetable, matter from which none of the inorganic matter, or rock material, has been permanently removed. Thus, when nature produces plants in native condition, there is no inorganic plant food removed from the soil and, in addition, there is considerable organic material produced largely from the carbonic acid gas of the atmosphere which is added to the soil on the death of the plant. In like manner the decay of the native vegetation and the accumulation of leaves in forests produce a soil of high fertility.

Crop Requirements. When the virgin soil is long cultivated by man, these conditions are changed. Practically all the crop is removed from the soil; organic matter is not added to the soil; and, besides, much of the inorganic plant food is removed by the crop.

The two most important plant foods are nitrogen and phosphorus, since they are the ones that are likely to be deficient in the soil and are the ones which have a market value and are the important constituents of commercial fertilizers. The crop requirements of the wheat, potato, and sugar beet plants for these substances are recorded in Table V. On the removal of the cultivated crops, such as wheat, potatoes, and sugar beets considerable amounts of these plant foods are taken out of the soil. Values of the plant foods removed with the crops are computed at the normal prices for which the elements may be purchased on the markets: nitrogen, fifteen cents a pound; phosphorus, three cents; and potassium, six cents.

It is important to note from the following table that the phosphorus is concentrated in the grain, and, therefore, in the most salable products of the farm. When the wheat

is sold from the farm, phosphorus is removed in large quantities. In grain crops such as wheat, two thirds of the nitrogen, three fourths of the phosphorus, and one fourth of the potassium are found in the seed. If the grain is sold, these amounts are lost to the farmer; if the grain be fed to live stock on the farm, one fourth of the nitrogen, one fourth of the phosphorus, and very little of the potassium are retained by the animal. That is, three fourths of the nitrogen and phosphorus may, with care, be returned to the soil. There is, then, a constant loss of these essential

Table V.—Crop Requirements

Product		Pounds			Market Value			
Kind	Amount	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium	Total Value
Wheat.....	50 Bu.	71	12	13	$10.65	$00.36	$0.78	$11.79
Wheat straw	2½ T.	25	4	45	3.75	.12	2.70	6.57
Wheat crop.....		96	16	58	14.40	.48	3.48	18.36
Potatoes....	300 Bu.	100	13	90	9.45	.39	5.40	15.23
Sugar beets.	20 T.	100	18	157	15.00	.54	9.42	24.96

plant foods from the farm. It would seem to be clearly indicated that in order to keep the soil in a fertile condition we must do as nature has done—make provisions for the addition of organic matter to the soil and for the return to the soil of those plant foods which have been removed.

Value of Rotation. In a permanent system of agriculture, it is necessary to practice a system of crop rotation. It must not be assumed, however, that a crop rotation alone will maintain the crop-producing power of the soil. It is difficult to conceive how such a system will add to the soil those plant foods, with the exception of nitrogen, which have been removed. There is a number of reasons why a crop rotation should be practiced. Probably the six most

important are the following: (1) elimination of weeds, such, for example, as the elimination of June grass from the alfalfa fields in the intermountain region; (2) the better control of insect pests; (3) use of a legume in order that the farmer may employ the free nitrogen of the air; (4) the introduction of the deep root crops, such as the alfalfa plant, which is undoubtedly the best subsoiler we have; (5) the varying demands of different crops upon the plant food supply. Thus, a maximum corn crop would remove nineteen pounds of potassium, while a corresponding sugar beet crop would remove one hundred and fifty-seven pounds. The alternation of such crops, therefore, would give a better chance for the liberation of this element from its insoluble compounds in the soil. A final reason is (6) an economical consideration, in that such a system provides for better utilization of machinery, labor, and irrigation water.

Barnyard Manure. Since rotations alone can not keep up the fertility, some fertilizing substance must be added. Barnyard manure is undoubtedly the best fertilizing material available for the farm. The value of the manure produced on the farms of America is estimated at two and one third billions of dollars, and yet one third of this amount or $800,000,000 worth, is, each year, wilfully wasted on the farms. The manure is valuable from a physical, bacteriological, and chemical point of view. It assists in converting the soil into a better physical condition, so that the soil retains and delivers the moisture to the plant in times of drought better than soil not manured. At the Rothamsted Station in England one plot has been treated with barnyard manure at the rate of 15.7 tons an acre yearly. Another plot has received mineral plant foods in about the same proportion as contained in the manure. The average yield of wheat on unfertilized land was 12.9 bushels, while that on the plot receiving mineral plant food was 27.1 bushels, as opposed to 35.5 bushels for the plot receiv-

ing barnyard manure. These results are the average of fifty-five years and are, therefore, trustworthy and reliable and indicate quite clearly the crop-producing power of barnyard manure. These results also show that mineral plant food can maintain the crop-producing power of the soil.

The years 1893 and 1903 were abnormal years, the former being extremely dry, and the latter was very wet. The results obtained these years are indicated below in Table VI.

Table VI.—Yield of Wheat in Bushels an Acre. (Rothamsted.)

	Unfertilized	Farm Manure	Mineral Plant Food
1893 Dry Year..	9.8	34.3	21.8
1903 Wet Year..	7.6	29.7	35.8

The results clearly indicate that, though in normal years mineral plant food is fully as valuable as the manure, during an extremely dry year the barnyard manure gave the best results, on account, no doubt, of the great power of soil so treated to retain and deliver moisture to the plant. The manure is valuable for its plant food content also. A ton of barnyard manure contains ten pounds of nitrogen, two of phosphorus, and ten of potassium, which at the average market price of these elements, fifteen cents per pound for nitrogen, six cents per pound for potassium and twelve cents for phosphorus, makes a ton of barnyard manure worth $2.34. The manure also supplies abundant food and energy for the bacteria of the soil. The decomposition of the organic matter brought about by bacterial action produces a number of organic acids which assist materially in rendering plant food available.

Green Manuring. Since the quantity of barnyard manure is limited, some substitute for its organic matter must be found. This end is accomplished by growing a crop for

the express purpose of plowing it under while it is still green. Thus, in some sections of the country, the clover crop is grown in a rotation and plowed under. Such a crop serves as food for soil bacteria and readily undergoes decomposition with the production of the organic acids so necessary to render plant food available for the higher plants. A crop grown for green manure should, if possible, be a legume in order to obtain the free atmospheric nitrogen in a combined form. Frequently a legume crop, called a cover crop, is grown in the orchard for the purpose of plowing under to increase the humus and nitrogen content of the orchard soil and to render other plant foods available.

Limestone. Older soils are poorer than newer ones. In addition to the plant food removed from the soils by crops, the older soils, in some cases, have lost from their lime content until they are acidic, or sour. Such soils are nonproductive, because the soil bacteria can not work to the greatest efficiency in soil that is acidic. Moreover, many of the higher orders of plants will not grow in such soil. The alfalfa plant and some other legumes, being lime-loving plants, will not thrive in an acidic soil. It thus becomes necessary to make large additions of limestone to the soil of many sections. Fortunately, most of the soils in the intermountain country are so well supplied with limestone that the alfalfa plant and other legumes grow luxuriantly.

Summary. There are, then, a number of important factors which determine the crop-producing power of the soil. The farmer must be constantly on the alert to exercise a favorable control over these factors wherever possible. If the soil is acidic in nature, this condition should be corrected by the addition of ground limestone; if the soil is heavily charged with alkali, it should be removed by drainage. The farmer in the intermountain country should make better use of barnyard manure and green manure, and should practice a system of crop rotation.

QUESTIONS

1. Name the six factors that determine plant growth.
2. Which of these can man control? How?
3. Why are virgin soils fertile?
4. How much plant food do crops use for each acre?
5. How do rotations help?
6. Explain why barnyard manure is so valuable.
7. When should green manure be used?
8. Discuss the value of limestone in the soil.

EXERCISES AND PROJECTS

1. Make a map of a farm showing the fields. In each field show the crops grown for several years.
2. Pour a few spoonfuls of hydrochloric acid in a glass vessel. Dilute with about the same quantity of water. Add a spoonful of soil. Foaming indicates the presence of lime. The more vigorous the foaming the more abundant is the lime.
3. Place a few spoonfuls of soil in two deep glass vessels. Fill with water and shake thoroughly. To one add a spoonful of lime. In a half hour shake both vessels again. Observe which clears first. The lime granulates the soil.

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CHAPTER XV

THE VALUE OF THE RAINFALL

It is well known that some regions are drier than others, that when plants wilt they do so because the supply of moisture is insufficient, and that plants grow rapidly after a rainstorm heavy enough to moisten the soil to any considerable depth. Just what is the value of rainfall in definite terms such as tons of hay or bushels of wheat can not be generally known with exactness.

Quantity of Rainfall. One region is rainy or wet, and another one is dry, in proportion to the amount of rainfall, which consists of rain, hail, snow, and sleet. Unless the amount of water that falls in a section is stated in definite terms, it is impossible to tell just how much rainfall the region actually has. For convenience rainfall is reported in inches of water. If all the moisture that falls in a year could be saved without loss, the depth in inches might be measured at the end of the year and reported. Where a part of the rainfall is snow, hail, or sleet, these must necessarily be melted and the depth of the water taken. Because some snow is much wetter than other, the depth of snowfall is not an index of the amount of water it contains. Since it is impossible to save the rainfall and measure it all at once, carefully devised vessels catch the moisture falling in each storm for separate measurement. These amounts are added to give the total precipitation for the year.

A region is said to be *humid* when ordinarily there is enough rainfall to produce crops without irrigation water. Regions that have too little rainfall for crop production without the practice of either irrigation or dry-farming, are said to be *arid*. Transitional regions, that is, those that lie

between, are called *subhumid* or *semiarid* regions. Sometimes these terms have slightly different meanings, but not usually. With ordinary soil and winds, 30 inches of rainfall during the year is usually enough to enable successful farming without special culture methods. Less than 20 inches is commonly taken as the amount of rainfall that requires irrigation or special tillage methods. Where there is between 20 and 30 inches, crops need more care than in a humid region, but not so much as in an arid section.

Figure 31.—Edge of snow drift. Catchment basin under Mt. Logan, Utah.

Distribution of Rainfall. More than half of the land area of the earth has too little rainfall for the most profitable agriculture. The most extensive areas of aridity are north and south Africa, Australia, except the northern coast, central Asia, southwest Asia, and southeast Europe, and the western parts of both Americas. In the United States the dry areas, beginning about middle Kansas and Nebraska, extend westward to the coast, except the western strip of Washington, Oregon, and northern California. The dry regions result from a combination of winds, latitude, oceans, and mountains that cause the rainfall to be scant or the evaporation to be high.

Some districts have storms throughout the year, at nearly regular intervals, whereas others have alternate periods of wet and dry weather. In California, for example, the rainfall comes almost entirely during the winter; in Utah, Nevada, and southern Idaho rather largely during the later winter

and early spring; in Arizona during July and August; in Montana and Wyoming during late spring and early summer; and on the Great Plains during the whole summer.

Where most of the precipitation falls in the growing season, plants make ready use of it; but where it falls before the crops are planted, or, at least before they begin to grow rapidly, much of it may be lost before the time of greatest need. Evaporation is high, however, when the moisture falls largely in warm weather. Clear, dry harvest weather is also a decided help.

If the rainfall is slow or in the form of snow, opportunity is afforded for it to sink into the soil. Heavy downpours, by compacting the surface soil and by emptying considerable quantities of water on the soil at once, encourage much run-off. Slow, drizzling rains are, therefore, preferable to sudden, torrential ones.

Small summer showers wet only the surface and are evaporated before they come in contact with the active roots. Larger storms are more efficient. It is better even to have the rainfall of dry regions all in one season of the year than well distributed in small storms.

Crop Yields. Some seasons are much more favorable to crops than others. Often much of this difference is due to a difference in rainfall. One year in Illinois 13½ inches of rainfall during the growing season produced 32 bushels of corn to the acre. The next year under similar conditions, save that 22½ inches of water fell in the growing season, 94 bushels were grown on each acre.*

Careful investigations have shown that a large part of any crop grown under irrigation is produced by the natural rainfall. About 750 pounds of water are used in western America for growing one pound of dry substance in the wheat plant. Counting one half of this to be straw, each inch of water on an acre will produce about 2½ bushels of

*Hunt's Cereals in America, p. 207.

grain, if no water is wasted. A 10-inch precipitation could supply a 25-bushel crop with moisture till maturity. Where there is a rainfall of 20 inches, large crops can be grown without irrigation.

Widtsoe (Principles of Irrigation Practice, p. 234) has estimated that under a light irrigation of 7½ inches, from 67

Figure 32.—One man should drive an extra team on the dry-farm.

to 84 per cent of the yields resulted from rainfall, and only 16 to 33 per cent from irrigation water.

Evaporation. Plants use only that part of the soil moisture which does not evaporate or drain off beneath. In deep soils of dry sections loss from percolation may be practically forgotten so far as rainfall is concerned. Evaporation, however, is extremely active. It is so intense that from two to ten times the total rainfall will evaporate from a water surface and twice this much from a wet soil. A person cannot but wonder how any water at all is left in the soil. Indeed it is little the plant will get unless great care

is taken to prevent losses by evaporation. The drier the air, the hotter the soil, and the freer the wind movement, the greater will be the evaporation.

Winds. If high, warm winds are common, they pump immense quantities of water from both the soil and the plant. The damp atmosphere immediately above plants is replaced by dry air which is thirsty for water. Only by getting the

Figure 33.—A reason why dry-farming has failed. The land is not harrowed.

moisture deep into the soil and by making a protective mulch on the surface, can it be saved at all under such conditions.

A great difficulty is that regions with little rainfall have hot, clear weather, warm winds, and dry air. As the available moisture in a farming section gets less and less, the difficulty as well as the importance of saving it becomes greater and greater.

Soils composed of particles that are nearly of the same size and that are neither too coarse nor too fine, permit water to move back and forth readily. Seams of gravel or hardpan, however, prevent this movement, and are, therefore, undesirable. Because they are not uniform, such soils are nearly useless for dry-farm purposes. To be effective as crop producers, the soils of dry regions ought to be six, eight,

or more feet in depth without gravel or hardpan of either clay or cemented materials. For agricultural purposes a soil has no more depth than that to which roots can go readily or from which water can rise freely to feeding roots.

Root Systems. In wet soils or in soils with a hardpan near the surface, plant roots do not penetrate more than two or three feet. In dry-farm areas on uniformly deep soils, wheat roots have been found at a depth of more than seven feet and alfalfa roots at more than twenty feet. It

Figure 34.—Why dry-farming has failed. Tumble weeds are allowed to grow on fallow land.

has been found that soils lose water from as much as fifteen feet below the surface in the case of grass crops. Water is drawn from some distance below the deepest roots. Many of our dry-farm crops have developed extensive root systems that enable them to feed many feet below the surface where evaporation is active. A good loam soil ten feet deep can hold twenty-five inches of water—enough to supply an enormous crop of grain or a good one of hay. Dry-farm tillage methods, which retain this water for plants, are the only necessities for a paying crop, if the soil is once thoroughly moistened.

Dry-farming is the name given that kind of farming in which there is special tillage to prevent evaporation. Until the last few years, dry sections were carefully avoided by

home-seekers, and perhaps wisely so. Investigations in Utah, California, and on the Great Plains, however, recently showed that it was possible to produce crops where care was taken to handle the soil properly and to choose crops that were drouth-resistant. Now, dry-farming is practiced not only in western United States, but in Mexico, western Canada, South America, North Africa, South Africa, Australia India, China, Asia Minor, Russia, Austria-Hungary, Spain, and other countries. The people of these countries are just finding out the possibilities of crop production under methods of water conservation.

The successful practice in dry-farming is based on a few fundamental principles, among which are:

1. Crops require more or less definite quantities of water for successful growth under given conditions.

2. Some plants use water more economically than others, and are, therefore, better adapted to the dry-farm.

3. All rainfall should be made to pass at once into the soil and be kept there, so far as possible beyond the influence of evaporation.

4. Careful tillage lessens evaporation and also causes plants to grow more rapidly and more vigorously.

5. If there is not enough rainfall in one season to produce a profitable yield, the land should be cropped only once in two years, the moisture of the fallow year being stored in the soil for the crop the following year.

6. Nothing except the crop should be allowed to grow on the land either when the crop is growing or when the land is being fallowed.

7. Only deep, uniform soils ought to be used, because shallow soils or ones broken by gravel or hardpans prevent root development and free movement of moisture.

8. Small profits from each acre of large tracts make comfortable incomes.

9. Machinery and animals necessary for rapid cultivation of large acreages should be available.

10. Man controls the whole situation by thin seeding at the proper time, and on good seed beds. This fact prevents more plants from beginning life than can mature with the water available.

QUESTIONS

1. How is rainfall measured? Who measures it in your community?
2. Why is western United States arid? Western Kansas? Central Asia? Northern Africa? India?
3. Describe an ideal rainstorm.
4. Describe a "good year" and a "poor year" for crops.
5. *Why* does water evaporate? Now *how* does it? *What* causes evaporation?
6. How much rainfall is there in your section? In neighboring towns? Explain difference or similarity.
7. How extensive are plant root systems?
8. How common is dry-farming in your region? In the United States? In the world?
9. Give the five principal practices in dry-farming in order of importance. State the theory on which each is based.
10. What is a cloudburst? A tornado? A typhoon? A chinook? A "rain belter"?

EXERCISES AND PROJECTS

1. Expose a straight-sided vessel during a heavy storm. Measure the depth of the rainfall. If the precipitation is snow, melt it first.
2. Set up some straight-sided cans, fill with water. Expose some in shade, some in sunshine, some to wind, and some to calm. Let stand for a few days. Note the loss by evaporation.
3. Compute the weight of an acre-inch of water. Of an acre-foot. Of a second-foot for 12 hours.
4. Look up the difference between the equatorial calms and the "horse latitudes." Why are there great belts of arid regions near the tropics of Cancer and Capricorn?
5. Map the humid, semi-arid, and the arid regions of the United States on a map. Indicate each by a different marking.

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CHAPTER XVI

STORING AND SAVING SOIL WATER

Water is of use to the growing plant only when stored in the soil, where the plant roots can absorb it. It has been demonstrated that, if sufficient water be stored in deep soil at the time of planting, there is little need of it during the growing period of the plant. The maintenance in the soil, therefore, of a sufficient supply of water is one of the very important considerations for successful farming.

Water-holding Capacity of Soils. There is a strong attraction between soil particles and water, as shown by the water film which clings around a stone after it has been dipped in water. Water added to a soil clings around the soil particles as a thin film in which the root hairs are bathed and from which the water necessary for plant growth is drawn. There are also in the soil varying quantities of so-called colloidal substances which, when mixed with water, form jelly-like compounds. Some water is held in the soil in this form. The total quantity of water that may be held around the soil particles and by the colloidal soil constituents without draining off represents the water-holding capacity of the soil. In coarse, sandy soils this is low, often going down to 10 per cent or less of the weight of the soil; in fine, clayey soils it may rise to 40 per cent or more of the weight of the soil. In loamy soils the water capacity is more nearly between 20 and 25 per cent.

A cubic foot of loam soil weighs in the neighborhood of 80 pounds. Assuming its water capacity to be 20 per cent, it would hold 16 pounds of water. A column of soil one square foot at the top and eight feet deep would then hold 128 pounds of water, equaling a trifle more than 2 feet of

rainfall. Since the capacity of soils for storing water is so large, it should be well understood by the farmer.

Downward Movement of Soil Water. When water is added to a soil, the particles near the surface take up all the water that they can hold. The excess passes downward through the soil pores, and as it moves downward the soil particles take up as much as they can hold. The depth to which water passes depends on the quantity of water added to the soil. If less water is added than is needed to satisfy the water capacity of the soil, most water will be found near the top of the soil and less and less at lower depths. It is important that as much as possible of the water that falls on the soil descend well beyond the reach of the sun's heat. To accomplish this result, the subsoil should always be kept somewhat moist; for water travels downward very slowly in a dry soil. This principle is of particular importance in countries where the rainfall is light. If so much water is added that it percolates freely to the standing water table or an impervious hardpan, the soil pores tend to become clogged with water, to the great detriment of the plant. No more water should be found in the soil than can be held against drainage by the soil particles. In order to promote best plant growth, the soil pores should be partially open.

Extent of Water Storage in Soils. In sections where most of the rainfall comes in winter, as in the intermountain region, a large part of the winter's precipitation can be stored in the soil for the use of the next crop. From 50 to 90 per cent of the water that falls as rain and snow during the winter is found stored in the soil, at seed time, when proper cultural methods have been employed.

In sections where the summers are wet, as in the Great Plains region, less of the water that falls can be stored in the soil; but, even in such places on bare soils, 35 to 75 per cent of the water that falls may be found stored in the soil at the close of the season.

That water may be stored in soils for the use of plants has been well demonstrated.

Storage for Biennial Cropping. The low rainfall of some sections makes cropping without irrigation rather uncertain. For such conditions the attempt has been made to store in the soil a large proportion of the rainfall of two seasons, to be used by one crop. By this method the land is left bare, or fallow, for one year and planted in crop the following year. In sections with winter rains, this method seems to be more successful than where the rainfall comes chiefly in summer. If the land is allowed to rest one year, however, provided it is kept free from weeds and volunteer crops, and is carefully cultivated, some of the moisture then gathered is carried over to the next year. There are many other beneficial effects of fallowing, that, combined with its water-storing power, make it an excellent agricultural practice in regions of low rainfall, where irrigation can not be practiced.

Cultural Methods. Reasonably deep plowing, to six or eight inches, tends to make it easier for the water to descend into the lower depths of soil. Deep plowing should be practiced cautiously, however, if the subsoil is somewhat lifeless or inert. On most arid soils it may be practiced with impunity.

Fall plowing is also a good practice for water storage, especially in regions of winter precipitation. Land well plowed and in a rough condition catches the drifting snow and absorbs the water.

To enable water to pass into the soil to be stored there, the top soil must be kept loose and spongy. Any treatment that will promote this condition will help the storage of water in soils.

Water Loss by Evaporation. Evaporation is the chief cause of loss of soil water. Water is very easily changed into vapor, which passes into the atmosphere. In most

localities the quantity of water that would evaporate, were it available, is much greater than the rainfall. Thus, at Fort Yuma, Arizona, 100 inches of water would evaporate annually from a free water surface, while the annual rainfall is only 2.84 inches. At Fort Duschene, Utah, 75 inches would evaporate while the rainfall is 6.49 inches; and at El Paso, Texas, the evaporation is 8.7 times larger than the rainfall; at Pineville, Oregon, 7.8 times; at Lost River, Idaho, 8.3 times; at Laramie, Wyoming, 7.1 times; and at Mohave, California, 19.1 times.

Water evaporates from a wet soil as from a water surface. As the water at the surface is evaporated, the water lower down in the soil slowly moves upward, and is in turn evaporated. The higher the temperature, the more abundant the sunshine, the drier the air, the stronger the winds, and the wetter the soil, the more rapid the evaporation.

Tillage to Reduce Evaporation. The large possible loss of soil water by evaporation must be reduced, or there will be no water left for the use of plants. This may be accomplished by stirring carefully the top soil. This leaves a blanket of loose dry soil over the land, which has been found to be an effective protection against water loss by evaporation. Such cultivation with a harrow or any other satisfactory cultivator, should be practiced after every rain or irrigation, and should be deep and thorough, though it is not advisable to form a dust mulch over the land.

Loss by Transpiration. Much water is also taken from the soil by plants. The tiny roots absorb water which is passed upward through the plant and finally evaporated chiefly from the leaves. This process, known as transpiration, is essential to plant life. The water taken from the soil contains in solution the necessary plant foods, and by the process of transpiration these are distributed in the plant. For every pound of dry plant substance produced, from about 300 to 2,000 pounds or more of water are

required. (See Chapter XV.) The average is probably not far from 500 pounds. The rate at which water passes through a plant depends on many factors. Transpiration is increased by a high temperature, abundant sunshine, a dry atmosphere, high winds, and a dilute soil solution, that is, a soil poor in plant food.

Controlling the Transpiration. It is practically impossible to control the temperature, sunshine, air, or winds to such a degree as to reduce transpiration. It is, however, possible to affect the plant food in the soil to such a degree as to change the transpiration. It is known that the more soluble plant food there is in the soil, the less water is required to produce a pound of dry matter. To get a larger crop with a given quantity of water in the soil, it is necessary to increase the plant food. This increase may be accomplished most directly by adding commercial fertilizers or by manuring. In one set of experiments, 908 pounds of water were required to produce one pound of dry corn. By adding to this soil an ordinary dressing of manure, this was reduced to 613 pounds. Keeping soils well manured is, therefore, one of the best methods of reducing the transpiration.

It has also been found, however, that the careful and thorough stirring of the top soil will reduce transpiration. In an experiment on a sandy loam, 603 pounds of water were required to produce a pound of dry matter; when this was cultivated, only 252 pounds were required. Cultivation no doubt promotes soil fertility, and, therefore, reduces the water cost of dry matter.

The system of fallowing, already discussed, also tends to liberate the plant food of the soil, and, consequently, on fallow soils less water is required to produce crops than on soils continuously cropped.

Plowing stubble or growing plants into the soil also increases soil fertility and reduces the water cost of crops.

QUESTIONS

1. In what way do soils hold water?
2. How does water move downward in soils?
3. To what extent may water be stored?
4. How does fallowing help? Cultivating?
5. How may evaporation be decreased?
6. Explain how plants may be made to use water economically.

EXERCISES AND PROJECTS

1. Dampen soil and fill several deep vessels three fourths full. Cover some with three or four inches of sand, some with straw, and have some uncovered. What happens in a week? Explain.
2. Dig a hole a foot deep in the soil. Fill with water two or three times. Next day dig down to find how far and in which directions the water has moved.

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CHAPTER XVII

SOWING AND CARING FOR DRY-FARM CROPS

Soil Preparation. An important feature of dry-farming is the preparation of the soil so that it will be a suitable bed for the germination of seeds. The plowing should be done when the soil is not too wet nor too dry, as either extreme will make it cloddy. The best tilth is secured by plowing the land when it contains just enough moisture to allow it to pulverize readily. Plowing done in the fall is usually better than that done in the spring, and deep plowing better than shallow. Eight to ten inches is usually a good depth.

It is a good plan to go over the land with some kind of harrow or leveler immediately after plowing, to prevent the formation of clods. When land is plowed in the fall, however, and is to stand over winter without a crop, it is wise to leave it unharrowed, especially in regions receiving much precipitation in the winter.

With new land it is advisable to prepare the soil considerable time before planting the seed, so that the soil may have a chance to weather and store moisture.

Germination. In the preparation of the seed bed the central idea should be to produce conditions favorable to the germination of seed. Many factors influence germination; the three most important are, heat, oxygen, and moisture.

There are not many ways in which the farmer can influence the heat of his soil. Thorough drainage, dark color, and coarse texture all favor an early warming of the soil and consequently promote a rapid germination of the seed. The oxygen supply is increased by loosening the soil. A soil which has not been stirred does not furnish sufficient air for the best germination of seed.

The most important single factor concerned in germination of seed on dry-farms is the soil moisture. It is often difficult to have the best quantity of moisture present at the season when seeds should be planted. If there is only enough water to start germination, the drying which follows reduces the vitality of the germ. It is often necessary to plant seed in dry soil and wait for a rain to furnish water for germination. This venture, at best, is unsatisfactory. It is much better, by means of the summer fallow or in some other way, to have sufficient moisture in the soil at the time of planting to bring the seed up.

Sowing the Crop. In the Great Basin, crops sown in the fall usually grow better than those planted in the spring, a result, no doubt, of the precipitation that comes in the winter. Fall varieties mature earlier than those planted in the spring. Such crops as potatoes must, however, be planted in the spring. Even for spring planting it is usually better to plow the land in the fall.

The small grains may either be drilled in or sown broadcast; but experiments have demonstrated the superiority of drilling. Disk drills followed by press wheels have been most successful. The object of the press wheels is to compact the soil firmly around the seeds to help them in absorbing moisture for germination. It is better, however, to compact just as little of the soil as possible.

In planting dry-farm crops great care must be exercised not to sow too much seed, since a heavy stand is likely to use all the moisture at first and leave none to mature the crop. With wheat, from one half to one bushel to the acre is as much as is wise to plant.

The depth to sow dry-farm seed depends on the condition of the soil and especially on the amount of moisture present. When the surface is dry it is often necessary to plant very deep, five or six inches, in order to put the seed in moist soil. If, however, the top soil has sufficient mois-

ture to bring the crop up well, it is advisable not to plant too deep. With the small grains, it is well to plant as shallow as a good germination can be secured; but, if the soil is dry, deeper planting is necessary.

Cultivation. After the seed is planted it is rarely necessary to do anything until the crop comes up, but as soon as the plants are well through the ground cultivation should begin. It is usually best to harrow the young crop every few weeks till the plants get so large that they are injured by harrowing. With the small grains, cultivation for the season usually ends at this time; but, with crops planted in rows, such as corn and potatoes, the cultivator can well be used very much later. Constant cultivation of crops is one of the chief keys to success in dry-farming.

Harvesting. The methods of harvesting dry-farm crops are not greatly different from those used for irrigated crops. Dry-farms are usually large and are consequently able to use large machinery with profit. The header, self-binder, and combined harvester are the chief implements used in harvesting small grains. The header and the combined harvester can be used successfully only where the ripening of the grain is fairly uniform. In harvesting corn and potatoes on dry-farms, machinery should likewise be used.

Storing and Marketing. Many dry-farmers, on account of not having proper facilities for storing crops, are compelled to sell when the market price is low. The equipment of the farm is by no means complete until there is some adequate way of caring for crops till market conditions justify selling. It is sometimes better to have arrangements for storage at an elevator on the railroad than to make special granaries on the farm. Such storage is often very economical. Prices of crops are as a rule low at harvest time; hence it often pays better not to sell at that time.

Crops for the Dry-farm. So far, the small grains have been the chief dry-land crops of the Great Basin. Of these,

wheat leads; barley, rye, and oats have all been raised successfully; and emmer has given some promise. Potatoes have been a very successful crop in some regions, but no great area has been devoted to them. As forage crops, both alfalfa and smooth brome grass have done well. Corn, in many respects, is a good dry-land crop. The fact that the rate of planting can be made to comply so easily with the amount of soil moisture, and that the uncropped space can be readily cultivated, make it particularly useful in dry-farming. In the Southwest, milo maize is one of the most profitable dry-farm crops. Some of the other sorghums are also promising. Sudan grass is proving to be an excellent forage crop in some sections. Each dry-farming region has crops which are particularly adapted to it. One of the difficult things in dry-farming is to get profitable crops that will make a good rotation.

Wheat raised on dry-farms is very much better than that raised under irrigation. It is harder and contains more nitrogen and gluten and consequently makes better flour. The straw of dry-land grain is superior for feeding to that of irrigated grain. Forage crops raised on dry-farms are especially valuable on account of the high percentage of nitrogen and dry matter that they contain. They seem also to have a higher percentage of leaves.

QUESTIONS

1. Why is it important to harrow dry-farm land immediately after plowing?
2. What are some of the conditions of a good seed bed?
3. What conditions favor the rapid germination of seed?
4. How does the amount of seed planted on the dry-farm compare with that used under humid conditions?
5. How do the yields of fall and spring varieties of grain compare in the Great Basin? What is the reason for the difference?
6. Why is cultivation so important in dry-farming?
7. What crops have been most successful under dry-farming?

EXERCISES AND PROJECTS

1. Make a box having one side covered with glass. Plant wheat or other grain at various depths—from one inch to eight inches—and cover with moist soil. The seeds are to be planted against the glass in order that the time of germination and the nature of growth may be noted. It is probably best to add some soil and then place the seeds against the glass and cover with soil. Repeat this until all the seed desired is properly placed and covered.
2. Place clay or clay-loam soil well pulverized into six vessels. Wet all of the soil thoroughly. Now allow to stand; when they begin to dry add a little water to five, leaving one to dry. Next day add a little water to four. Each day add water to one less. This should be so regulated as to have the wetness of the soil at the end of the experiment vary from very wet to right dry. Now take a sharpened piece of wood and draw through soils as a plow would move. Note the relative ease of cultivation with different degrees of wetness. Allow to stand until all are dry. Note results.

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CHAPTER XVIII

MEASUREMENT OF WATER

In the United States the "cubic foot per second" is the unit generally used to designate the volume of moving water. In the measurement of flowing water there are two elements to be considered, the area of water front, multiplied by its velocity, or rate of its flow. The velocity of flowing water is most often measured by its rate of flow in a second.

Second-foot. If we assume a channel to be one foot wide and the depth of water in the channel to be one foot, we then have an area of one square foot. If we assume that the flow of water in this channel is at the rate of one linear foot a second, there would pass a given point one cubic foot of water each second. The flow of this stream would be one cubic foot per second, or, as frequently designated, one second-foot. If the channel were five feet wide and the depth of water three feet and the rate of flow of the water two feet a second, the channel would be carrying ($5 \times 3 \times 2 = 30$; area $\times$ velocity = volume) thirty second-feet.

Acre-foot. The term acre-foot is most frequently used to designate the amount of water contained in a reservoir or the depth of water applied to land by irrigation. An acre-foot of water is the amount that would cover an acre to the depth of one foot, or 43,560 cubic feet. A second-foot flowing continuously for twenty-four hours equals 1.98 acre-feet, or, as commonly expressed, "A second-foot for twenty-four hours equals two acre-feet."

Miner's Inch. The miner's inch is a measure deriving its origin from an attempt of the early mining and irrigation interests of the West to devise a method of measuring water in natural and artificial channels. The quantity of water

represented by a miner's inch is variable, because it is subject to the statutes of various states. The miner's inch is measured by means of a rectangular opening in a channel. The depth of water over the top of the opening varies from 4½ to 6 inches. It takes from 48.4 miner's inches in Colorado to more than 70 inches in Dakota to equal one cubic foot a second; hence the miner's inch is fast going out of use.

The Gallon Measure. The gallon measure is used extensively by engineers in calculating the supply of water for municipal purposes. The flow of water is expressed in the number of gallons that would flow in a minute of time. A gallon equals 231 cubic inches, and it requires 7.48 gallons to make one cubic foot, or 448.8 gallons per minute to equal one second-foot.

Methods of Measurement. To determine the rate of flow of any channel it is necessary, as stated above, to know the area of the channel and the velocity of the water. The width is determined by direct measurement with line or surveyor's instrument. The depth is taken at intervals across the stream near a bridge or by means of a car run on a cable. The velocity is most frequently determined by the use of a current meter or by means of floats.

The current meter consists essentially of a series of vanes or cups revolving horizontally around a vertical axis. The number of revolutions of the meter is determined in relation to the velocity of the flowing water in which it is held. The meter is lowered into the water; a sounder held to the ear gives clicks for turns of the vanes, which are counted. Thus, by the use of the current meter, the velocity of the water can be ascertained. The meter is used in determining the velocity of water in large and small streams. It is generally necessary to measure a stream in several places as the velocity varies considerably. The middle flows faster than the sides; the top, faster than the bottom; and the center, faster than the top. To multiply the

width by the depth and this result by the velocity means that averages must be used. Now, averages are extremely hard to get for either the depth or the velocity; hence quick measurements are very crude, and careful ones can only approximate the flow. A large stream ought, therefore, to be computed by sections.

Floats are, as the term implies, objects placed upon the surface of the water and allowed to float with the current. The rate at which the float travels between two given points will determine the rate of flow of the stream. Surface floats are subject to action of winds and currents and measure only the rate of the flow of the surface water, and hence do not give an average. The submerged float is frequently used and consists essentially of the surface float having suspended from it by means of a small wire some kind of a weight. The use of any float gives only approximate results.

The rating flume usually consists of a rectangular flume or channel permanent in its nature. The velocity of the water in the flume is determined by the use of the current meter at times of different depths of water in the flume, the flow of the stream being calculated thereby. From these measurements and calculations a table is made so that knowing the depth of water in the channel at any time, the flow of the channel can be ascertained by reference to the table.

The Weir. The methods of determining the flow of water enumerated above may be termed direct methods.

The weir is a means of determining the total flow by the application of principles and formulas derived from experiments. In the use of the weir, the velocity of the water is estimated as it passes through the opening. A weir consists essentially of a regularly formed opening of definite shape and size. There are three forms of weirs: (1) the rectangular weir having a horizontal bottom and vertical sides; (2) the trapezoidal, or Cippoletti weir, the bottom of the opening being horizontal and the sides having a slope of one

measure horizontal to four vertical; (3) the triangular or V-shaped weir, whose sides slope forty-five degrees, which is sometimes used in measuring very small quantities of water. The trapezoidal weir is the one generally used.

The weir is well adapted to the use of engineer or layman. It measures the depth of water passing through the opening. Then, either by calculation or from tables, the flow of water is readily determined.

In measuring the depth of water passing over a weir crest, the measurement of the depth or head must be made at a point a few feet up stream from the weir. The water in passing over the crest of the weir has a curved upper surface and the experimental depth is the one measured above the point where this curvature occurs.

Inches of Water. In many sections of the West there has come into use a term, inches of water, which derived its origin from placing rectangular boxes of desired sizes in the canal. The size of these boxes, or openings, was determined by the number of shares of stock owned in the ditch by the individual or individuals using water from this opening. No attention was paid to the depth of water above the opening or the grade or slope of the boxes or of the flume leading away from the opening. If, for instance, a person's interest in a canal entitled him to one hundred inches, he would have placed in the bank of the canal a box ten inches by ten inches inside measurement. If he were near the head of the canal he would have from one to three feet of water above this box, while near the lower end of the canal he might have but a few inches. Thus, the man at the head of the canal might, and, by actual measurements, did, receive from one and one half to three times as much water as the man at the lower end of the canal.

In the division of water in natural streams and in artificial channels the early courts have decided that the respective openings should be of a specified width; but in few,

if any, cases did the court specify the grade of the channel at and immediately below the division.

This method of measure or division is very rapidly passing out of use.

Automatic Devices. There have been invented, within the past twenty years, numerous automatic measuring and dividing devices most of which have been especially designed to deliver to the users from the canal a definite quantity of water. Because the water of western streams fluctuates from day to day, and even during the day, and also because during a part of the irrigation season the water is turbid, or has vegetable matter floating upon it, these devices have proved unsatisfactory.

Kutter's Formula. By numerous experiments and trials there has been found a formula for the calculation of the flow of water in natural and artificial streams. This formula is known as Kutter's formula, based upon the action of gravity upon water. Where the channel is uniform and regular, the formula gives fairly good results. It is used extensively by engineers, especially for preliminary work and for the designing of sizes and grades of artificial channels. It is, however, so complicated that only specialists can use it.

QUESTIONS

1. Why should water be measured?
2. Define second-foot, acre-foot, miner's inch, current meter, float, rating flume, and weir.
3. How is water measured?
4. Why do some men get more water from canals than others?
5. Describe an automatic device for measuring water.
6. What is Kutter's formula?

EXERCISES AND PROJECTS

1. If possible, practice measuring a stream at a weir or flume. This may be done in either of two ways. The simpler way is to find a weir and to measure the width of the weir crest (at bottom of

notch) and to measure depth of water on a nail which is set level with the weir crest some distance back of the notch. The quantity of water can be read directly from a table. This table can most likely be secured from the county agricultural agent or from the State Engineer's Office at the state capitol.

When no weir is nearby, the measurement may be approximated by measuring the depth and the width of the stream in a flume or in a straight place in its natural bed. It is now necessary to find the velocity of the stream. This can be done roughly by measuring off twenty, thirty, or sixty feet and finding how many seconds it requires to float a chip that distance. The volume of the stream can now be found in second-feet by multiplying the width in feet by depth in feet by velocity in feet to the second.

Note: This sort of measurement is only approximate.

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CHAPTER XIX

THE QUANTITY OF WATER TO USE

Over the surface of the whole earth less water flows in the rivers than is necessary to cover the land by irrigation. In the arid and semi-arid regions particularly the water in the streams is sufficient to cover only about one tenth of the land that could be irrigated profitably. The most important question before the irrigation farmer is, therefore, "How can I make the water go as far as possible?"

Irrigation a Supplementary Practice. The purpose of irrigation is to supplement or assist the rainfall. Even in arid regions, except in the driest, the rainfall is of chief importance in producing crops. The value of the rainfall has been demonstrated in many places. It is common knowledge that in wet years larger yields are obtained with the same irrigation water than in dry years. It has also been found that one half to three fourths of a normal irrigated crop is really attributable to the rainfall, that is, by dry-farming methods one half to three fourths of the irrigated crop would have been obtained. To save irrigation water, therefore, the rainfall should be stored and kept in the soil, just as is done in dry-farming. The more of the natural precipitation thus stored, the less irrigation water will be needed. It follows that in regions of high rainfall little irrigation water will be needed. In fact, in humid regions irrigation is of benefit only in dry years.

The First Law. After the rainfall has been well conserved in the soil the first law to guide the farmer in the application of irrigation water is that "*the crop-producing power of each unit of irrigation water diminishes as the total quantity of water used is increased.*" This law means that,

if 5 inches of water produced 38 bushels of wheat, 10 inches would not produce twice as much. In fact in a long series of experiments it was found that 5 inches of water produced nearly 38 bushels of wheat, but 50 inches or ten times as much water produced only about 49 bushels—a gain of about 11 bushels for 50 inches of water. The following table shows some of the results obtained in experiments:

TABLE VII.—Yields of Dry Matter, in Pounds per Acre with Varying Quantities of Water. (Utah Results.) (Rainfall and Soil Water = 13.74 inches.)

Inches of Water Applied	Wheat	Corn	Sugar Beets	Potatoes
5.0	4,969	.....	6,080	2,310
7.5	5,545	10,757	.....	2,730
10.0	5,684	12,762	8,053	2,925
15.0	6,279	13,092	8,636	3,405
20.0	.....	13,865	10,076	4,005
25.0	6,672	14,606	.....	.....
30.0	.....	15,295	10,271	3,660
35.0	7,229	.....	.....	.....
50.0	7,999	.....	11,528	3,795
55.0	.....	12,637	.....	.....

As more water is applied, therefore, to agricultural crops the smaller does the yield become for each unit of water used. If too much water is used, the yield actually decreases. In general, therefore, where there is plenty of land and little water, it should be profitable to use as little water as possible and spread it over the largest area of land.

Spreading Water over Much Land. In the above table 5 inches of water produced 37.81 bushels of wheat, whereas 50 inches produced only 49.38 bushels. If the 50 inches had been spread over 10 acres, to a depth of 5 inches, there would have been a yield of 378.1 bushels of wheat. Where water is expensive and land cheap, such a consideration becomes more important. Similar calculations may be made for the other crops in the above table, and on the basis of

the cost of production the most profitable quantity of water to use may be calculated for each crop.

Water and Crop Development and Quality. Changing the quantity of water used does not alone affect the total yield of crop. The development of the crop is powerfully affected by the quantity of water used. The proportion of

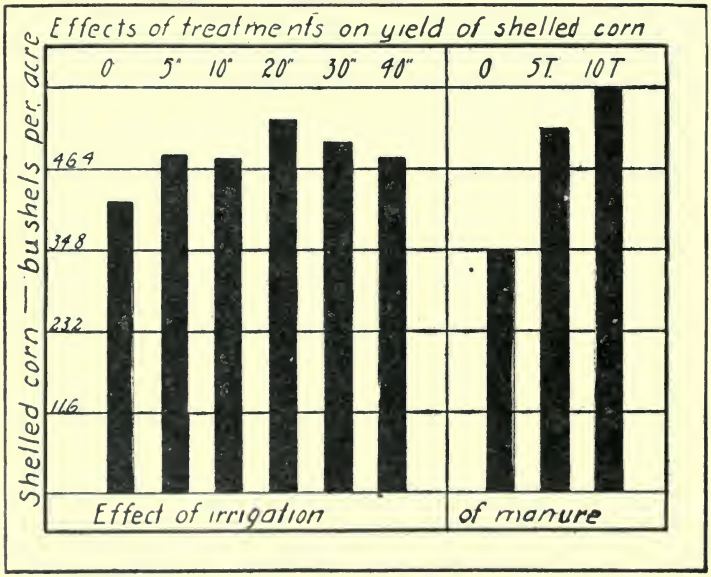

Figure 35.—The effect of varying quantities of water and manure on the yield of corn.

roots in a plant becomes smaller as water is increased. A somewhat dry soil is rather better filled with roots than is a wet one. The general vigor of the plant depends on the condition of the roots, and a medium supply of water will furnish the best root development. The seed-bearing stalks, the leaves and other parts of the plant are most favorably affected by medium quantities of water. In all grain crops the proportion of grain goes down as the irrigation water is increased, that is, with much water straw is produced at the

expense of grain. For example, the proportion of grain in wheat falls from 44 to 33 per cent as the water is increased; in oats from 65 to 58 per cent; in barley, from 51 to 38 per cent and in corn, from 52 to 44 per cent.

The chemical composition of crops is also affected by the quantity of water used. The per cent of gluten in wheat

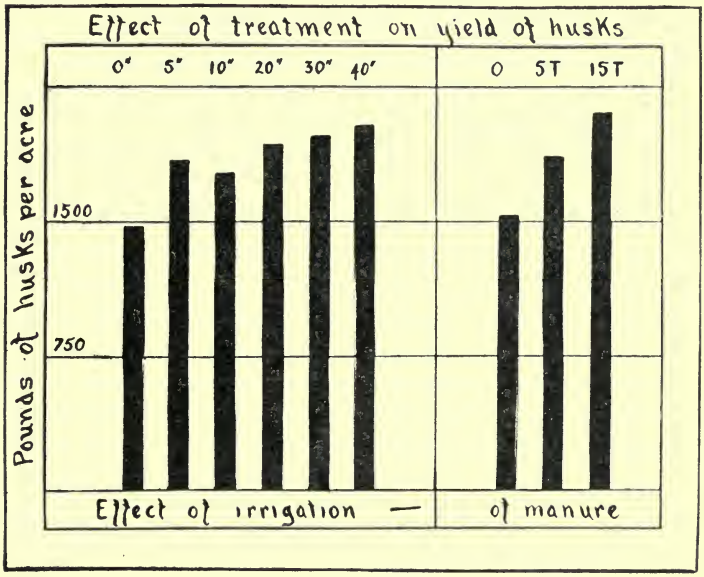

Figure 36.—Effect of varying irrigation and manuring on the yield of corn husks.

and the sugar in beets becomes smaller as much water is used. The color and flavor of crops are best when the crops are lightly irrigated. While some crop constituents are favored by heavy irrigation, most of the desirable qualities of crops are obtained by light irrigations.

Quantity of Water to Use. It is exceedingly difficult to lay down any definite rules governing the quantity of water to be used for different crops. On the basis of general experience and reported experiments tolerably safe limits may,

however, be stated. Wheat requires relatively little water. On deep well tilled soils 7½ inches of water in two irrigations should be sufficient; on shallow, gravelly soils, as high as 18 inches may be used in 4 or 5 irrigations. An average of 1 acre-foot should be ample for the production of wheat on fertile well tilled soils. Oats should not receive less water than wheat; barley about the same; but rye may be grown with less water than the other small grains. Corn should seldom receive more than from 12 to 18 inches of water.

Alfalfa can make use of more water than the grains, and should receive from 12 to 24 inches of water according to the age of the crop and the depth of the soil. Ordinarily 18 inches should be enough. The other haymaking crops, like timothy and orchard grass, need even less water than a crop of wheat. They are cut only once, while alfalfa is cut three times or more. Clover requires probably from 12 to 15 inches of water. Pastures and meadows should receive according to location from 12 to 24 inches of water.

Under present practice sugar beets receive from 15 to 24 inches of water; but the tendency is for somewhat less to be used. Carrots and other root crops should receive about the same. The more seed is planted, the more water is required. Potatoes need a good supply of water in the soil at planting time. The total quantity should be about the same as that for sugar beets.

It is fairly safe to say that all ordinary crops, including trees and shrubs, should receive from 12 to 24 inches of water. This amount is considerably less than is now applied to crops. As better cultural methods are employed, the duty of water will become higher, that is, less will be used per acre. Water has been used quite wastefully in the past.

QUESTIONS

1. Why ought water to be used economically?
2. What part does rainfall play in crop production under irrigation?

3. Why is light irrigation more profitable?
4. How may water be made to produce greater crop returns?
5. How does heavy irrigation affect the quantity used?
6. How much water should be applied in one irrigation?
7. How many irrigations are necessary for crops? Why does this vary?
8. How often should crops be irrigated? Why does this vary?

EXERCISES AND PROJECTS

1. Secure a half dozen tomato or other cans of the same capacity. Make holes in the bottom of each with a nail. Fill with moist but not wet soil. Hang in a row in such a way that the cans are level and firm. Using a small vessel (a desk ink-well would serve) add water slowly to each can, noting how many vessel-fuls are added to each before water begins to drip through the holes. The capacity of soils to hold water helps to determihe how much water may be applied to irrigated lands. ne
2. Secure a deep can. Make holes in it. Obtain enough soil of the same kind to fill it several times. Fill it one fourth full and see how much water may be added before dripping begins. Empty this soil out, and fill half full with soil. Add water until dripping begins. Repeat with can three fourths full and then full. Use fresh soil each time. Compare the quantity of water that was added in each case before dripping began. The depth of a soil is also a factor in determining the best size of application of irrigation water.

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CHAPTER XX

THE TIME AND METHOD OF IRRIGATION

To obtain the best results in crop production the soil should contain, throughout the growing season, approximately the same percentage of water. To maintain this condition is impossible. Rains do not come regularly; nor is the water used in irrigation equally available throughout the season.

Plant Growth and Irrigation. In the spring, when the root system is being developed, the growth of plants above ground is slow. The rate of growth increases, however, until the time of bud and flower formation when it is most rapid. When seed formation begins, the rate of growth diminishes. The water used by plants is generally in proportion to the rate of growth, because many of the factors that determine plant growth also determine the rate of evaporation.

As a general principle, then, little water needs to be applied to crops when they are young; more, as the time of flowering is approached, and less thereafter.

It is very difficult to approximate this ideal, since stream flow does not vary with the needs of the farmer. Only when water is stored in reservoirs from which it may be drawn as needed can the ideal principle be applied. For the best crop results, however, every effort must be made to supply the crop with water at the right time.

Time of Irrigating Short-season Crops. Wheat and the other small grains, peas, beans and similar short-season crops should be planted in soils well-filled with moisture. They should then be allowed to grow as long as possible without irrigation, in order that a vigorous and strong root

system may be established. Early irrigation of such crops is seldom advantageous enough to pay for the labor and water. If the soil were well moistened at the time of planting, it is seldom necessary to irrigate before the time of flowering. From that time on, one or two irrigations may be profitably applied. After the seeds are well formed there

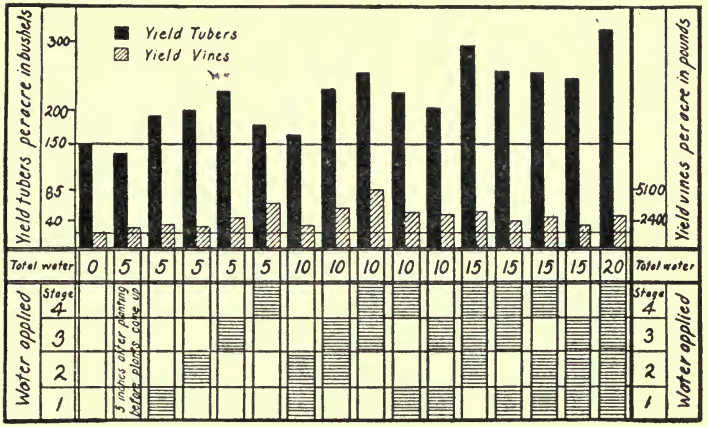

Figure 37.—Effect of varying irrigation on yield of potatoes.

is seldom any advantage in irrigation, though, when the seeds are filling and shortly before, water is of great value.

Time of Irrigating Long-season Crops. Sugar beets, potatoes, corn, alfalfa and similar long-season crops should be planted in well-saturated soil. The first irrigation should be postponed as long as possible, until the plants really show the need of water. From the time of the first irrigation, water must be applied to these long-growing crops at regular intervals.

Sugar beets, carrots, corn and like crops, planted usually in May, need the greater quantity of water in July and the first half of August. From the first of September and during autumn, little, if any, water should be applied, even if the harvest does not occur until October or November.

Four or five inches of water form a fairly large single application. Usually a smaller quantity is sufficient to maintain the crops in good condition. Two to four irrigations throughout the season should be sufficient.

In the case of alfalfa the first irrigation should occur just before the time of bud formation, and another just before or after each cutting.

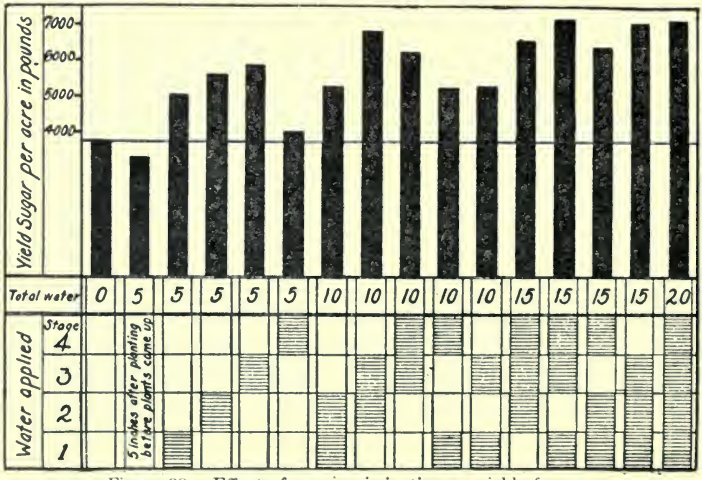

Figure 38.—Effect of varying irrigation on yield of sugar.

Fruit trees require a moderate quantity of water in spring and early summer with an increasing quantity as the summer advances and the fruit develops and the fruit buds form. Late fall irrigation of orchards, after the season's wood has ripened, is beneficial to the succeeding crop, except in places where the winter precipitation is heavy.

Fall and Winter Irrigation. Wherever the rainfall or snowfall comes chiefly in fall and winter or in early spring, fall and winter irrigation have little value, if the land is so treated as to allow the natural precipitation to soak into the soil. Wherever the winters are dry, fall and winter irrigation are very desirable.

It is of the greatest advantage to have the soil well-filled with moisture at planting time, for it makes possible a quicker and more complete germination, and it delays the time of the first irrigation and consequently the plant is enabled to establish a strong root system. In all districts, therefore, where the soils are naturally dry in the spring,

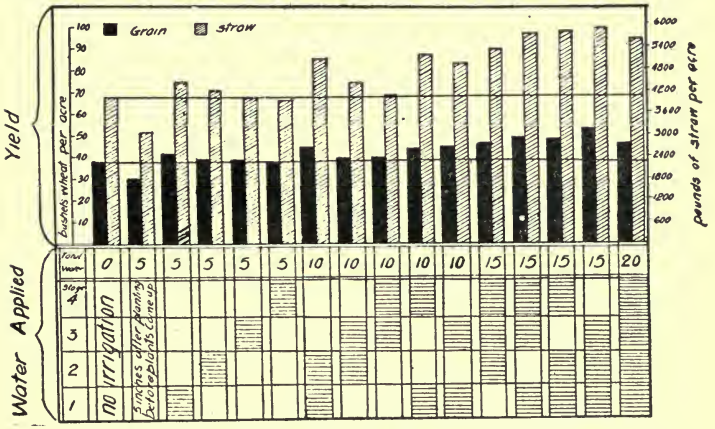

Figure 39.—Effect of varying irrigation on yield of wheat.

fall, winter or early spring irrigation may be advantageously practiced.

Fall irrigation may be applied to the land any time after harvest; winter irrigation at any time when the soil can absorb water, and spring irrigation any time before planting.

Methods of Irrigation. The methods of irrigation are many, but they are all variations of three general methods, namely, (1) flooding the land; (2) applying the water to the land in furrows, and (3) subirrigation. In general practice the first two alone are in general use.

Irrigation by Flooding. Most commonly land is flooded by taking water out of the main ditches at various intervals, and, as it flows over the field, distributing it properly

by small temporary ditches or furrows. These small laterals follow the high places of the field, and the water overflows their banks, thus covering the field. This is the so-called field-ditch method of flooding. A variation of this method is the border method in which the field is divided by low flat ridges of earth into long narrow strips, the lower ends of which are open. Each strip is flooded separately. Another very common variation of the flooding method is the check method in which the field is laid off into compartments or checks wholly surrounded by banks or levees, which prevent run-off. Water is admitted at the upper end until the compartments are wholly covered.

Furrow Method of Irrigation. In this method of irrigation, small furrows, leading from the supply ditch, traverse the fields to be irrigated. Water flows down the furrows without overflowing and is absorbed by the soil. Next to the method of flooding by field ditches, this is the most common method of irrigation, and promises, at least in America, to supersede all other methods.

The furrows used in this method are usually temporary and made from year to year by "markers" or "furrowers."

Subirrigation. The application of water to crops from below would be very satisfactory were it not that it is very expensive to install suitable underground systems for the distribution of water and that plant roots move towards the openings through which water issues, and in time choke them up.

The only subirrigation of consequence is that practiced under naturally favorable conditions. In some localities are somewhat sandy soils one to five feet in depth, underlaid by an almost impervious clay. Ditches are dug at intervals of a hundred yards to three fourths of a mile. The water flowing through these ditches sinks until it reaches the clay bottom when it spreads over great distances and within reach of the plant roots. This limited natural sub-

irrigation is the only form of applying water from below the surface which can be recommended at present.

Permanent Ditches. Whatever method is used, a system of permanent supply ditches should be laid out on every farm. Such an arrangement makes the farm look better, and also saves labor and expense from year to year.

QUESTIONS

1. What is the ideal soil moisture condition?
2. Why do young plants require only small quantities of water?
3. How should the irrigation of long-season and short-season crops differ? Why?
4. Ought irrigation to be practiced in fall or winter? Why? How?
5. Describe the various methods of distributing water on the land.
6. Compare flooding with the furrow system.
7. Describe the conditions where subirrigation should be practiced.
8. Explain the law of "least resistance" as applied to time, method, and extravagance of irrigation.

EXERCISES AND PROJECTS

1. Fill four pie plates two thirds full of moist sand. Plant about 200 kernels of wheat in each. Keep two of these moist. Let two dry out. Wet them again and allow to dry out. Repeat this. Note results for two weeks.
2. Mark off two areas of clayey ground or spread out two patches about six feet long and three feet wide. Flood one of these. In the other, make furrows and add water by running it down the furrows. When dry apply water again. Now let stand until completely dry. Note the condition of the surface of the ground. Explain which would be more favorable for crops.

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CHAPTER XXI

ALKALI SOILS

ORIGIN AND COMPOSITION

Soils in which water-soluble salts have accumulated to such an extent that they are injurious to vegetation are spoken of as "alkali soils." On account of their method of formation, they are limited in area almost exclusively to the arid regions of the world, occurring but seldom where the annual rainfall exceeds twenty inches. In the arid regions, however, they often cover great areas and are of especial interest to the student of western agriculture.

Origin. We have seen that soils are formed by the gradual disintegration of the native rocks, which yield various substances that are soluble in water. In the humid regions, the heavy rains leach much of this soluble material from the soil and carry it to the ocean. In the arid regions the rainfall is not sufficient to accomplish this result and the soluble substances accumulate in the soil in sufficient quantities to become injurious to vegetation, under which conditions we have what is known as alkali soils. Our attention is often first directed to this condition after the injudicious use of irrigation water on the arid soils. A study of this harmful practice illustrates the way in which alkali soils are formed. When water is applied to soil, it tends by force of gravity to sink to lower levels. In so doing it seeks the larger openings and spaces in the soil; so water may pass down through the soil without becoming very heavily charged with soluble substances from it. When the water evaporates from the surface of the soil, that from the lower depths tends to rise to the surface to take the place of the water evaporated. As the soil water gradually climbs to the sur-

face, it becomes laden with soluble constituents. These, as the water evaporates, are deposited at the surface in quantities sufficient to act as a poison to the plant. There are numerous examples of this throughout Montana, Idaho, Utah, Colorado, California, and other western states.

Appearance. Soils which have been the shore of a sea or lake may also be so charged with soluble salts as to be classified as alkali soils. These have been formed by the

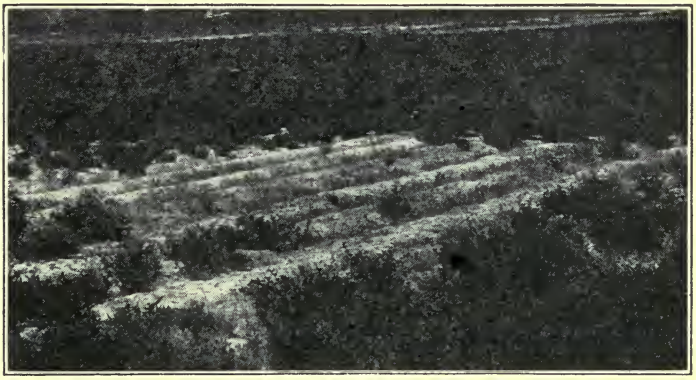

Figure 40.—Alkali spots in alfalfa field. The evaporation of the surface water has brought the alkali to the surface. Grand Junction, Colo. (Photo by E. D. Ball.)

evaporation of the water which has covered them, while the salts of the water have been deposited on the soil. Many of the alkali soils of the Great Basin have been formed through the slow evaporation of the waters of Lake Bonneville. The two classes of soils are, however, distinct in their properties. The true alkali soils are, after reclamation, extremely fertile, but the lake shore soils may or may not be; and these latter are usually much more difficult to reclaim than the former.

Alkali districts vary from a spotted field, in which only a small area is affected, to the one which is a barren waste. Alkali soil may have a brownish tint, appearing as if oil had been poured over its surface or it may be so covered with

salts that it is white. A white soil, however, does not necessarily indicate alkali, since some soils may be so rich in lime as to be white, and yet be free from alkali. The native vegetation, such as salt grass, greasewood, saltbush, and shadscale, indicate the presence of alkali in the soil, even though no traces may appear at the surface. On the other hand, sagebrush and rabbit brush usually indicate the absence of alkali. The presence of alkali is often first brought to the attention of travelers in alkali regions by its effect upon their skin and lips, giving them a dry, parched appearance, and often making the lips sore. Where alkali is being brought to the surface in cultivated land by the injudicious use of irrigation water, it usually appears first as a white or brownish incrustation along the edge of the furrows. This is often followed with a growth of barley grass (foxtail), which is usually regarded as intermediate between the cultivated crop, before the land becomes badly affected with alkali, and the worst stages, where the salt grasses grow.

Kinds of Alkali. The main injurious constituents occurring in alkali soils are sodium chloride, or common salt, sodium sulphate, or Glauber's salt, sodium carbonate, and frequently sodium nitrate. Soils which have been the bed of seas or lakes contain, in addition to the above constituents, magnesium chloride, or bittern, magnesium sulphate, or Epsom salts, and calcium sulphate, or gypsum. Where there is a large amount of any or all of the above salts, except sodium carbonate, it is known as white alkali. It is not necessarily white in color, but is nearly free from sodium carbonate. Where there is considerable of the sodium carbonate present, it is spoken of as black alkali. It is so-called from the dark color which this constituent imparts to the soil when it comes in contact with the organic matter of the soil. It is very destructive to plants, tends to puddle the soil, and clings very tenaciously to the soil particles, thus being hard to wash out.

EFFECTS

How Alkali Affects Plants. When there is considerable alkali in the soil, it may prevent the germination of the seed, or make a sparse, sickly growth, with short shoots which are only scantily clothed in leaves, and with little or no fruit. Sometimes the plants make a rapid healthy growth at first, only to be quickly killed outright when the alkali starts to

Figure 41.—Soil so heavily charged with alkali that the only vegetation which can grow on it is small annual salt bushes. Salt Lake Valley. (After Gardner and Stewart, U. S. D. A. Bureau of Soils.)

rise. On examining the plants, "we shall mostly find that the visible damage has been done near the base of the trunk, or root crown, rarely at any considerable depth in the soil itself. In the case of green, herbaceous stems, the bark is found to have been turned to a brownish tinge for half an inch or more, so as to be soft and easily peeled off. In the case of trees, the rough bark is found to be of a dark, almost black, tint, and the green layer underneath has, as in the case of herbaceous stems, been turned brown to a greater or less extent." The alkali may be in quantities sufficient actually to decompose seeds and it has been known to destroy completely the hard outer bark of mature trees. Small quantities of these same alkalies increase plant growth, probably on account of their stimulating action on the soil

bacteria. If large quantities are present, the alkali retards or may even kill the bacteria which are essential to maintain the productiveness of the soil. It is probably due to a lack of these bacteria and the bad physical conditions of the soil from which the soluble salts have been removed that the reclaimed soils are not productive during the first few years.

Quantity Injurious to Plants. The quantity of alkali which plants can withstand varies greatly with the plant and the soil. In general, where the soil is a loam or heavier, the amount of alkali required to injure the crop is higher than when the soil is more sandy. Alfalfa and beets are fairly resistant to alkali, while wheat, peas and celery are more sensitive to the salts. The following table gives the quantity of the various salts found by Hilgard to be injurious to some of the more common plants. The results are given as pounds an acre to a depth of four feet.

TABLE VIII.

Total Alkali		*Sodium Sulphate* (Glauber's salt)	
Salt grass	381,110	Saltbush	125,640
Saltbush	156,720	Alfalfa (old)	102,480
Alfalfa (old)	110,328	Sugar beets	52,640
Sugar beets	59,840	Salt grass	44,000
Wheat	17,240	Wheat	15,120
Apples	16,120	Apples	14,240
Alfalfa (young)	13,120	Alfalfa (young)	11,120
Mulberry	5,760	Mulberry	3,360
Sodium Carbonate (Sal soda)		*Sodium Chloride* (Common salt)	
Salt grass	136,270	Salt grass	70,360
Saltbush	18,560	Saltbush	12,520
Sugar beets	4,000	Sugar beets	10,240
Alfalfa	2,360	Apples	1,240
Wheat	1,480	Mulberry	1,240
Apples	640	Wheat	1,160
Mulberry	160		

These results show very clearly that the quantity of alkali which is required to kill plants varies greatly with the plant and kind of alkali. The so-called black alkali is more

toxic to plants than is the white alkali on account of its injurious effect on the physical properties of the soil.

RECLAIMING ALKALI LANDS

Prevention. Land that is known to contain considerable alkali but not sufficient to be injurious to plants should be so handled as to prevent alkali accumulation. Soluble constituents, when distributed to a depth of three or four feet, may so stimulate plant growth that the field may be very fruitful; but if these same substances are concentrated near the surface they may render the soil wholly unfit for the growth of plants. The accumulation of alkali may often be prevented by the judicious use of irrigation water. Where there is no underdrainage, the water used should be only what the plant requires. Surface and not subirrigation should be practiced; crops should be grown which shade the soil. In general, a method which reduces surface evaporation should be used. Care should be taken to see that the irrigation water used is not carrying sufficient alkali to the soil to injure it.

Figure 42.—An orchard being injured by alkali. Underdrainage or other corrective measures must be taken to prevent entire loss.

Use of Gypsum. A favorite method of reclaiming black alkali lands is by the use of gypsum. When this substance is applied to land rich in black alkali, it is changed into white alkali, which, as has been previously shown, is much less injurious to plants. Unless there be great quantities of black alkali in the soil, addition of the required amount of gypsum to the soil will render it fruitful. If, however,

there is already a great accumulation of white alkali in the soil, this treatment would have little value unless followed by drainage. Only a careful chemical analysis of the soil can tell whether this method of treatment will remedy the evil. The gypsum, besides neutralizing the black alkali, probably increases greatly the tilth of the soil and renders the alkali more easily leached out.

Alkali-resistant Plants. It has been shown that there is a great variation in the resistance of plants to alkalies, so that it may be possible to grow beets with profit on land which contains sufficient alkali to prevent the growth of wheat or fruit trees. The continual growing of alkali-resistant plants on the land and their complete removal gradually removes some of the alkali constituents, and in time it may be reduced to such an extent that less resistant plants can be grown with profit.

Cultivation. Alfalfa is quite resistant to alkali when once started; yet the young plant is very tender. It is often possible to get a good stand of alfalfa started on land by turning the top alkali under to a considerable depth, in order that the young plants may become rooted in the surface soil, which is comparatively free from alkali. By shading the soil or by surface cultivation it is often possible to reduce greatly surface evaporation and by so doing to prevent the accumulation of alkali at the surface. The application of manure to alkali soil often assists considerably by improving the physical condition of the soil. It has been recommended by some that the surface alkali be scraped up and then carted from the land. This method is of value only on small areas.

Underdrainage. The most successful method for reclaiming alkali land is by the leaching out of the soluble constituents by means of water. In order that this be a success, there must be a good underdrainage and the water applied in sufficient quantities to pass down through the

soil and to carry the alkali with it. It is in reality the only permanent method, since it is the only one that completely removes the cause.

QUESTIONS

1. What is meant by alkali lands?
2. From where does alkali come?
3. How does alkali rise to the surface of soils?
4. State the value of alkali land.
5. Name the kinds of alkali salts. Describe how each looks.
6. In what ways does alkali injure plants?
7. How much salt must be present to injure crop plants?
8. How may alkali be avoided on lands not impregnated?
9. Describe a method of reclaiming alkali land.
10. What crops are alkali-resistant?

EXERCISES AND PROJECTS

1. Collect pictures of alkali spots, and of plants injured by alkali.
2. Add various alkali salts to damp soils—a tablespoonful of each to a pie plate half full. Mix thoroughly and let stand. Note results. Explain.
3. Add a teaspoonful of the various alkali salts to water glasses about two thirds full of moist soil (one to each glass). Treat two glassfuls with each salt. Mix the soil thoroughly on a smooth surface or on a small piece of oilcloth. Plant ten wheat kernels in each and cover with glass. Note how soon the wheat comes up in each case.

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CHAPTER XXII

DRAINING IRRIGATED LANDS

That any of the irrigated lands of the West should require drainage seems strange at first thought. The early condition of western lands was that they were thirsting for water. This conception is still popular. The actual condition is, however, that a part of the land under irrigation is water-logged.

Development of Irrigation. The area of irrigated lands in the West has been increased greatly from year to year with the progress of settlement. The first settlers upon the streams constructed ditches and canals to irrigate lands immediately along the stream. When this area of land was cultivated, a ditch or canal at a higher elevation was built, covering lands at a greater distance from the stream and at a higher elevation. This development of the older, irrigagated sections has progressed until, now, lands are irrigated from the banks of the stream to the base of the mountains.

The causes which have led to the water-logging of irrigated lands and to the rise of alkali to the surface may be attributed to the gradual increase in the irrigated areas, to wasteful irrigation, and to seepage from artificial channels, all combined with lack of natural drainage.

The upper edges of wet land are extending, from year to year, farther up and are encroaching more and more each season on land hitherto not water-logged. This movement of the upper edge of the wet land can be arrested only by drainage or by the discontinuance of overirrigation.

Effect of Surplus Water in Soils. An excessive amount of water in soils leaches out plant food and excludes the air required by the plant for breathing. The result is excessive

evaporation, forming of cold soils with poor tilth, and accumulation of alkali at the surface.

Soil and Subsoils. The surface soils are usually rather porous and the subsoils in irrigated sections are more or less impervious to water. Thus irrigation water penetrates the surface soil to a layer of clay or hardpan which generally slopes toward the middle of the valley. The impervious strata, therefore, naturally form beds along which the water flows, if there is more than can be retained by capillarity.

Wet or water-logged lands occur most frequently at, and immediately below, a change in the general slope, especially at the foot of bench lands. Lands are less likely to be so situated on extensive plains than in mountain valleys.

Drainage in the United States has been confined, until recent years, to the humid sections. During the past eight or ten years considerable attention has been paid to the drainage of arid lands, and especially to those under irrigation. This work has received the attention of State Experiment Stations and of the U.S. Department of Agriculture.

Arid vs. Humid Drainage. There is a vital and fundamental difference between drainage in irrigated sections and that in humid regions. In a humid district, the excess of water is the result of rain falling upon the surface, while, in an irrigated one, it is due to water applied artificially or to seepage. Invariably the water that causes the water-logging comes by underground movement. The source of this may be water applied at higher levels or seepage from ditches and canals. The water from either source penetrates the surface soil to the impervious stratum along which it makes its way, until it finds a surface outlet or its rate of flow is lessened by denser soil or a more gradual slope.

In the humid sections the principles of drainage are based upon the fact that the water comes from all over the surface and must be removed from beneath the whole surface.

In arid sections, the need is not so much to remove excess water from the soil as to prevent it from entering the soil. In one case we seek a cure; in the other, a prevention.

Soil water moves always in the direction of least resistance. The rate of movement depends upon the supply, the slope of the soil and subsoil, and the fineness of the soil through which it moves. In the valley floors of irrigated areas the soils and subsoils are of such irregular texture that the ground water moves more as a slow stream in defined channels than as a general seepage through an entire section. This last fact modifies to some extent the general principle of drainage of irrigated lands.

Plans for drainage lines and systems must have for their starting point a suitable outlet. Many systems have failed for the reason that an outlet of sufficient capacity or depth was not provided.

The next general principle is to cut across the flow of the underground water. Crosscutting the flow of underground water corresponds to turning the water of a river or creek by placing a dam across it.

In draining for the removal of alkali salts the system corresponds to that of drainage in the humid section; that is, water is placed upon the surface of the soil by artificial means and after having percolated through the soil to the desired depth (three to five feet) must be carried off by artificial drains. The system must, of course, have sufficient fall to carry away the water and the sediment which may enter.

If the purpose of the drainage is to remove both surplus water and alkali salts, a system combining the principles of both is employed, the removal of the alkali usually being the secondary consideration.

The depth of drains depends upon the character and depth of the subsoil and the character of the crops to be grown. It is desirable to have the drains in irrigated sec-

tions at least four feet deep. If the crop to be grown is fruit trees, alfalfa, or some other deep-rooted crop, the drains should be at least five or six feet below the surface. The depth of the stratum carrying the underground water influences very largely the depth to which the drains are laid. When impervious subsoil is, as in some cases, only one or two feet below the surface, the drains should be bedded partly in this impervious subsoil.

Soil water wells, which are simply artificial openings in the ground, deeper than the level of the ground water, are used primarily to determine the height of ground water. They are used also to determine roughly the rate of movement of the water through the soil. After the drainage system has been established these wells are useful to indicate the influence of the drains upon the level of the underground water. They consist either of a hole bored with a soil auger or of one dug with a spade and afterwards boxed in.

The Kind of Drains. Open and covered drains are both used. The *open* drains consist essentially of a trench or ditch dug to the depth desired. They are not economical, as they are expensive to maintain, occupy a considerable land area, and are usually partly filled with dirt or clogged with vegetation. To be permanent they should have side slopes of not less than two lengths horizontal to one vertical.

The *brush* drain is closely associated with the open one. It consists merely of brush laid in the bottom of an open channel and covered with earth. This drain has proved unsatisfactory and expensive, since the brush soon decays and permits earth to fall into the trench, thus destroying its usefulness.

The *rock* drain is of two kinds, the loose-rock drain and the placed-rock drain. The loose-rock drain consists of cobble rock of various sizes thrown in the bottom of the trench and covered with earth. The placed-rock drain consists of a rectangular opening made by standing flat rocks edge-

wise on either side of the trench and laying another on top of these and covering with earth.

Wooden-box drains, as the name implies, are made of lumber and consist of rectangular openings usually from four to six inches by ten to twelve inches, most frequently without a wooden bottom. In place of a bottom, cleats from four to six feet apart are nailed across. These drains have given excellent satisfaction where the ground is continually moist; but in sections where the ground is comparatively dry a part of the year the wooden drains soon rot.

Tile drains are made by placing in the bottom of the trench burnt-clay or cement-concrete pipes. The tile pipe is preferable to any other kind of drain on account of its greater durability. If of good quality, tile pipe will last a lifetime. Although the cement-concrete pipes are acted upon to a limited extent by alkali, they are practically indestructible, and, next to burnt-clay, are to be recommended.

Many persons have the idea that water enters a tile through pores; but this is not true. It enters the joints.

Precautions. The failure of many drainage systems can be traced to faulty construction of incidentals. The tile should be laid in such a manner that the alignment will not be destroyed easily. Sand basins, or catch basins, as they are sometimes called, ought never to be omitted. These basins are for the purpose of catching the sediment carried in the system and also for the purpose of readily locating points that have become clogged. The catch basins, merely enlargements of the drainage line, are made usually of a wooden box a foot or two below the bottom of the drain, and with the top on a level with the surface, covered with a strong wooden lid. The outlet of a drainage system should be protected by a good screen against the entrance of rats, mice, and other small animals.

In constructing drainage lines it has been the practice of some to cover the tile with straw or similar perishable

material. The straw, being on top of the pipe, is, after a short time, in dry earth. It then affords an excellent nesting place for field mice, which burrow from the surface to the straw, leaving a hole. When the land is later irrigated, the water pours down these holes washing soil with it, thus enlarging the holes considerably. A clogging of the drains naturally results.

Clogging of the Drainage System by Roots. There has been considerable anxiety as to the possible destruction of drainage systems by the penetration of plant roots. Especially has this fear been felt where the line passed in the vicinity of trees, through alfalfa fields, or fields of other deep-rooted crops. This fear has proved poorly founded, since in not many instances has the failure of drainage systems been caused by root action. In northern Utah the greatest danger has arisen from the penetration of the tile lines by the sugar beet roots, which have frequently penetrated the tile and completely clogged it. The remedy is to plant no sugar beets within three or four feet of the tile.

Advantages of a Drained Soil. A soil which is drained has several advantages over a soil which is not, whether the drainage be artificial or natural. (1) The drained soil permits ready pulverization; (2) it is warmer; (3) it is lighter; (4) the growing season is lengthened, because the land may be worked earlier in the spring; (5) the rise of alkali to the surface is prevented; (6) the soil contains more air; (7) since the water table has been lowered, the roots have more soil from which to feed; (8) as plants can use only the capillary water, they get more from a deeply drained soil; and (9) as a result of all these benefits, crop yields are increased.

QUESTIONS

1. How is overirrigation related to alkali spots?
2. In what way does soil structure influence alkali?
3. Where do alkali spots occur most frequently?

4. In what sections of the United States is drainage practiced?
5. Wherein does the drainage of arid and humid regions differ?
6. Where should drains be laid with respect to water movement?
7. What is the proper depth for drains?
8. Name and describe the kinds of drains. State the value of each.
9. Give a few precautions necessary to a good drainage system.
10. How do roots affect drains?
11. List the advantages of draining.

EXERCISES AND PROJECTS

1. Collect pictures concerning land drainage.
2. If convenient, visit a drainage system that is being installed.
3. Add eight tablespoonfuls of common salt to a tomato can full of sand. Mix thoroughly and place in a can with holes in the bottom. Add water until about a cupful has drained through. Taste this water. Evaporate it.
4. Add four tablespoonfuls of common salt to each of two cans two thirds full of soil. Mix thoroughly. Add water until the soil is muddy and then let stand in can until dry. Do the same with sodium carbonate, sodium sulphate, and gypsum. When all are thoroughly dry, add water. Note the quantity of water and the length of time required to cause draining for each salt.

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CHAPTER XXIII

MACHINERY FOR PLOWING AND CULTIVATING

The plow is the most important of all farm implements. Its use dates back to ancient Egypt where it was first drawn by man and later by animals. Even as recently as the time of the American Revolution the plow was a crude affair, built by the united efforts of the village carpenter and blacksmith. The modern plow hardly began to develop until 1830. Greater progress has been made in the improvement of the plow since then than in all previous time.

Kinds of Plows. Modern plows may be classified as: (1) The walking plow, (2) the riding, or sulky plow, (3) the gang plow, (4) the disk plow, (5) the hillside plow, and (6) the subsoiler. The walking plow is fitted with either a wooden or a steel beam, each of which has advantages. The wooden beam may be broken, but is comparatively easy and inexpensive to replace. On account of the shrinking and swelling of the wood, more or less difficulty is encountered in keeping the metal parts attached to the beam from becoming loose and out of adjustment. The steel beam has a deeper throat than the wooden beam and for this reason is less likely to allow the plow to become clogged by tall weeds or cover crops when these are being turned under. This beam is less likely to be broken and is not so much affected by the weather; but it may be sprung when the plow strikes an obstacle.

Shares. The walking plow, as well as the sulky and the gang, is furnished with two general types of bottoms, the chilled and the soft-center steel. In the chilled plow, the share, moldboard, and landslide are made of cast-iron, very hard and well adapted to resist wear. As new shares of this

type cost but a few cents, it is quite inexpensive to replace them when they become broken or dull. They cannot be sharpened by forging, but may be sharpened by an emery wheel.

The chilled plow will not scour well in some soils, hence the steel plow is employed. The steel plow of best quality is made of a plate of steel so soft that it cannot be tempered, welded between two plates of cool steel. This arrangement leaves the center soft to resist breakage and the outside hard to resist wear. Shares made in this way are much more expensive than the chilled shares, but can be sharpened by a smith when they become dull and may be repointed by welding on new metal.

Plow bottoms are classed as general purpose, stubble, and breaker. The general purpose plow, as its name implies, is used for general work on land that has been cultivated; but it is not well adapted to breaking tough sod. For this purpose the breaker plow, having a long, slanting moldboard, is used, the effect of which is to turn the sod over in long strips, or ribbons. This turning over leaves the roots in condition to rot quickly and become available plant food. The stubble plow is best adapted for cultivated land, as it breaks up the furrow slice and pulverizes it better than either of the other types. This plow has a short, abrupt moldboard which produces the desired action.

The set of a plow consists in the proper relation of beam, share, moldboard, and landslide. Manufacturers see that the proper set is given to each plow before it leaves the factory, and the smith must be depended upon to restore this set each time the plow is sharpened.

The sulky plow has decided advantages over the walking plow in that it enables the operator to ride, causing him much less fatigue. The advantage is still greater in the gang plow with which one man may do much more work in a day than would be possible with a single plow. The selec-

tion of a sulky, or a gang, plow should be made with even greater care than in the case of a walking plow, because there are so many more working parts to be considered, and because the efficiency of the implement depends upon the proper adjustment and relationship of all these parts.

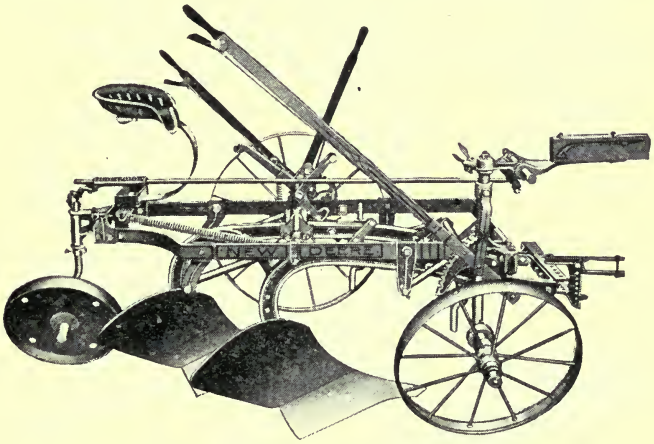

Figure 43.—Gang plow with detachable shares.

Sulkies should be conveniently arranged, easy of operation, and of good material and workmanship. A poorly constructed tool is likely to be composed of poor material. The plow should be provided with an easily operated foot lift and should be capable of turning a square corner in either direction. All wearing parts should be of generous proportions and either easily adjustable or capable of being replaced at small expense. These plows are made either with or without frames, the frameless plow being less expensive but not quite so handy in operation and rather less durable.

In the adjustment of a sulky plow, the land wheel should travel directly to the front. The rear furrow wheel should be given a small lead from the land, that is, it should be

turned outward slightly; it is also set about an inch outside the line of the landside in order to remove friction from this part of the plow. The front furrow wheel is given lead from the land with a single plow, and toward the land on a gang plow when the team is hitched abreast, causing the plow to travel directly forward. The horses should be hitched in such a manner that they will not be crowded

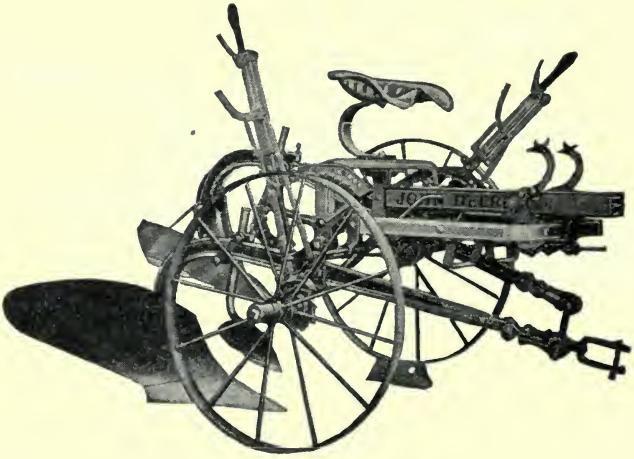

Figure 44.—Two-way sulky plow.

too closely together nor should they be too far apart, since in either case they cannot do their best work.

The two-way sulky plow is well adapted to plowing on hillsides where the land is too steep to furrow uphill. As the frame is wide, the plow will not tip over under these conditions. There is an automatic foot lift provided, by means of which either bottom is lifted by the team; but sidehill work is only one of the functions of these plows. They may be used as a right or left-hand sulky, and they are especially well adapted to plowing irrigated land, because the plowing can be started at one side of a field and

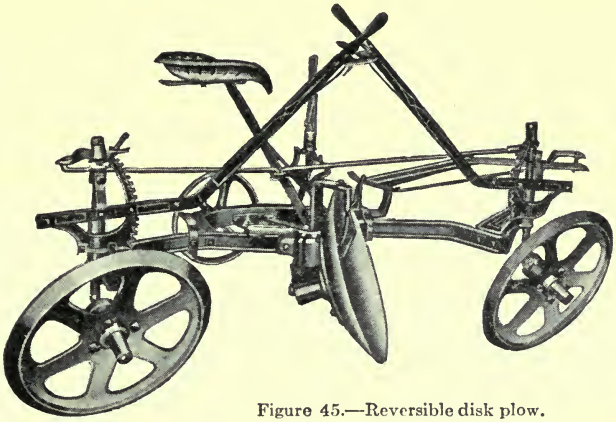

Figure 45.—Reversible disk plow.

carried directly across from one side to the other without back furrow ridges or dead furrows, thus leaving the land level and in good condition for further cultivation. They also have advantages in a dry country where it is desirable to follow the plow immediately by harrow and seeder to prevent the drying out of the soil. These plows are furnished with either jointers or rolling coulters, as desired.

The disk plow may be used on certain kinds of soil. The moldboard plow, however, is generally preferable, because it is lighter of draft, more convenient to handle, and easier to keep in repair.

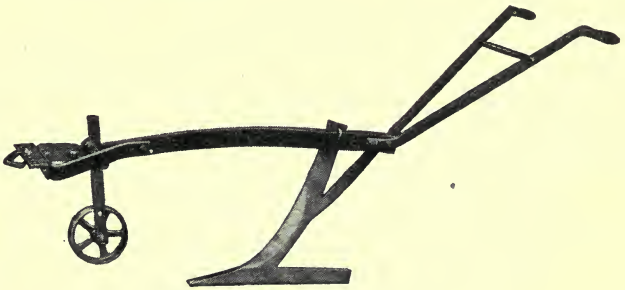

Figure 46.—Taylor subsoil plow.

The subsoil plow is not used to turn a furrow, but is intended to follow the ordinary plow in the same furrow, for the purpose of loosening the ground to a greater depth without bringing any of the subsoil to the surface. This kind of plowing makes more plant food available, and renders

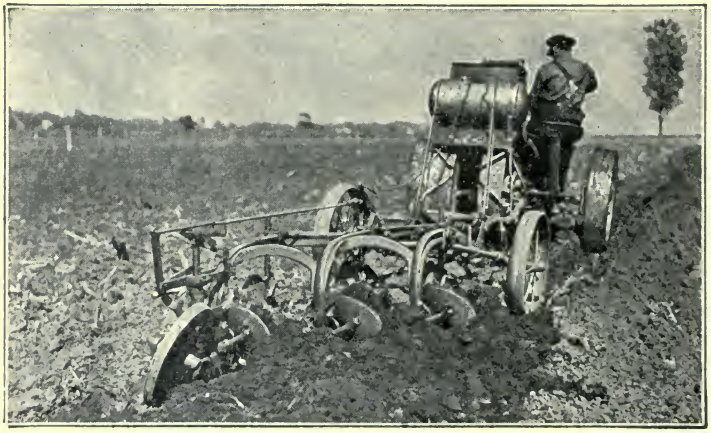

Figure 47.—Light tractor; one-man plowing outfit.

penetration of the plant roots to a greater depth easier. In some localities it pays to subsoil for some crops.

The Traction Engine. With extensive methods of farming the traction engine has come into use. Both steam and gas are used as a source of power. Some of the common uses to which the tractor is put are to plow, seed, and cultivate the ground; harvest the crops, haul gravel trains, draw road graders, pump water, pull stumps, saw wood and lumber, and haul farm products to market. The tractor is better for some of these purposes than for others. Its usefulness for plowing and cultivating purposes is still undetermined in many portions of the intermountain territory, because there are so many different soils. In some cases it is maintained that the tractor packs the soil to the

detriment of the crop. In other cases it seems a success, being good for plowing virgin land. If the ground is soft, provision is made by which an extension rim can be bolted to the wheels and thus distribute the weight over a larger area. By this means the ground has a less tendency to

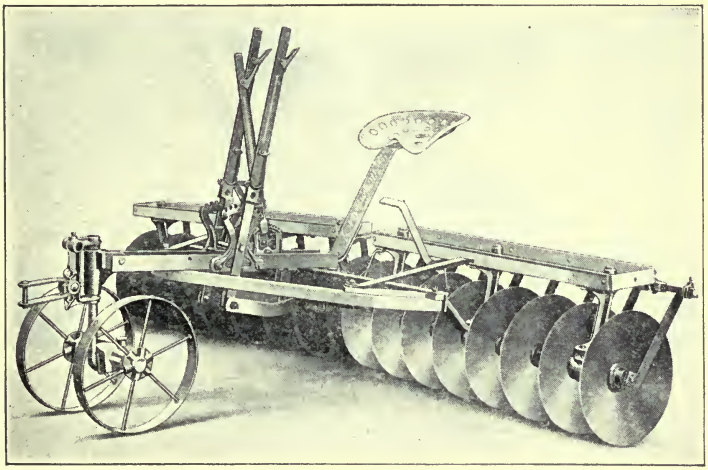

Figure 48.—Disk harrow.

pack. Farmers sometimes make a mistake in buying a large traction engine without having sufficient work to keep it busy. Deterioration and interest on the investment amount to considerable. A small tractor that will pull two or three plows will meet the needs of the majority of farmers. It is quite difficult to estimate the cost of plowing on account of the difference in cost of fuel for different locations.

Disk Harrow. To secure the best results plowing must be followed by the right kind of cultivation. One of the best implements to follow the plow is the disk harrow. On account of its rolling motion and its wide range of adjustment this machine may be used for a great variety of

purposes and under varying conditions of soil and climate. The disks vary in size from twelve to twenty inches, fourteen to sixteen inches being used most. The disk harrow should be well-made, furnished with good bearings and a simple, sure oiling device. Some disk harrows are provided with a single lever for regulating the angle of setting

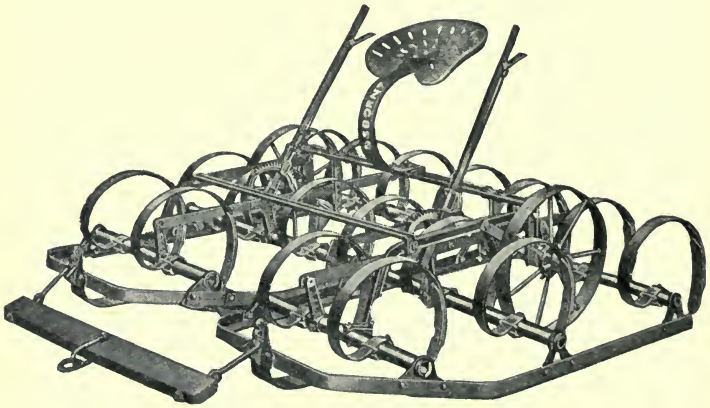

Figure 49.—Spring-tooth harrow.

of the gangs; but two levers are better, as the gangs can then be set independently of each other. To secure best results disks must be kept sharp, as they lose power of penetration when dull.

Spike-tooth Harrow. The spike-tooth, or smoothing harrow, is used to fit land for seeding after plowing is completed, and also to cultivate some crops soon after they are up. It breaks the crust that may have formed after rains, producing a dust mulch to retain moisture and destroying the small weeds. The best implements are provided with levers and quadrants by means of which the teeth may be slanted forward or backward or held in a vertical position. The teeth should have heads on their upper ends to prevent them from being lost in case they become loosened. The tooth fasteners should also be strong and simple.

The spring-tooth harrow is very useful on stony or rough ground. When the teeth catch on an obstruction, they spring back and in this way release themselves. They are made in several sizes and either for riding or walking.

Cultivators. These machines should be provided with substantial wheels and dust-excluding axle boxes; the operating levers should be conveniently placed. Heavy springs should be provided to assist in raising the gangs, and convenient means for steering are necessary.

One-row cultivators have shovel teeth on a frame of adjustable width. One horse pulls the implement, a man walking behind to guide it by handles.

QUESTIONS

1. Name the various parts of a walking plow.
2. What is meant by the plow bottom?
3. What special benefits does the two-way plow offer above other plows?
4. Name the different kinds of harrows in order of their importance as implements on the farm.
5. In what way has the tractor improved farming methods?

EXERCISES AND PROJECTS

1. Visit some Implement House and examine the different types of plows and harrows. See whether you can identify the implements described.
2. Find a plow or a harrow out of working condition. Repair it.
3. Find a rusty plow. Scour it clean with ashes and water. Now apply a little oil and rub. In half an hour or next day rub with dry ashes. Here is one way to clean a rusty plow.

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CHAPTER XXIV

MACHINERY FOR SEEDING AND HARVESTING

Seeds are commonly planted either by a seeder or a drill. The seeder should not be used except where it is impracticable to use the drill. The principal objection to the seeder is that is it impossible to place all the seed in the ground at the proper depth or with any uniformity of distribution.

Drills. The classification of drills is determined by the kind of furrow opener and the nature of the feed. There are various kinds of furrow openers such as the hoe, shoe, single and double disk openers. For most purposes the single disk is the best. It will penetrate the soil to a greater depth, is not so readily clogged by brush, has fewer working parts, and is less expensive. There are, however, several types of double disk on the market that are very successful. The double disk has no side draft and is efficient for clean, well-prepared ground.

Following behind the furrow opener is a covering device. The press wheels seem to be the most satisfactory for this purpose, especially for fall grain. One objection to this type is that uniform pressure is not always exerted. Another is that in some lands the press wheels pack the soil and cause rapid evaporation of moisture from the surface. A chain attached to the furrow opener is a good covering device for moist soils, but is not generally satisfactory for the soils in climates of limited rainfall.

Drills are equipped with one of two types of feeds, the external or internal feed. The former is used more than the latter. The amount of seed sown in the external feed is determined by the size of the opening. On the other hand, in the internal feed the amount of seed sown is determined by the speed of the cup ring regulated by a change of gears.

Mower. The mower consists of a cutting mechanism made up of a reciprocating tooth knife, or sickle, driving wheels, gearing to impart proper speed to the knife, and outside and inside dividers to keep the cut grass in proper position. The knife slides between guards and is driven by a pitman rod operated by a crank. It is very necessary that provision be made to adjust the worn parts to keep the mower in perfect working order. Most mowers are now provided with a foot lift by means of which the cutter bar may be lifted over obstructions and the horses relieved while turning corners. In some machines the bar may be lifted vertically a foot or more and automatically thrown out of gear and again put in gear when the bar is lowered to its working position. Figure 50 shows such a lifting mechanism. In order to do satisfactory work the knives must be kept sharp. A proper knife grinder is shown in Figure 51. The two-horse mower is the most common size and has a cutter bar from four and a half to eight feet in length. One of these machines is capable of cutting from eight to fifteen acres per day. The most essential features of a mower are accessibility for repair and provision to take up the wear in the various parts.

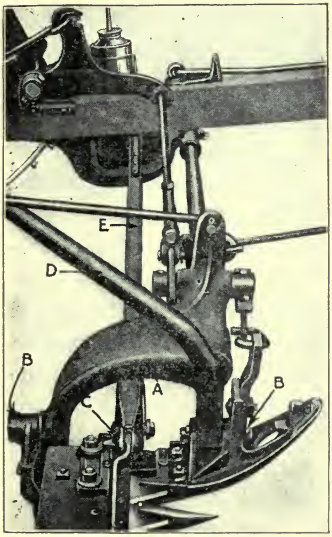

Figure 50.—Lifting mechanism of the mower.

Rake. There are several types of rakes on the market. Each works successfully for certain kinds of duty. The most common is the sulky rake, varying from eight to twelve

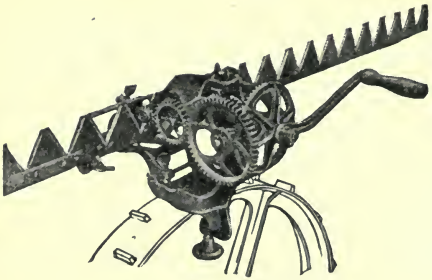

Figure 51.—Knife grinder.

feet in width. The side-delivery rake is used to advantage with the hay loader. The parts subject to severest shock and wear are the teeth and wheel boxes. Figure 52 shows a mower, side-delivery rake and a hay loader.

Binder. The binder is one of the most complicated machines among the many farm implements. The multiplicity of parts makes it essential that the various operations occur at the right time. The binder has a main driving wheel, gearing for power transmission, a cutter bar, a reel to gather the grain and place it on the platform, and canvas elevators to carry the cut grain to the binder attachment where it is gathered into bundles and tied.

The most important of all these parts is the binder attachment. The success of this part determines to a large extent the success of the implement. The knotter of this attachment very often gives trouble on account of its being improperly timed. Figure 57 shows a binder attachment;

Figure 52.—Modern haying machines in operation.

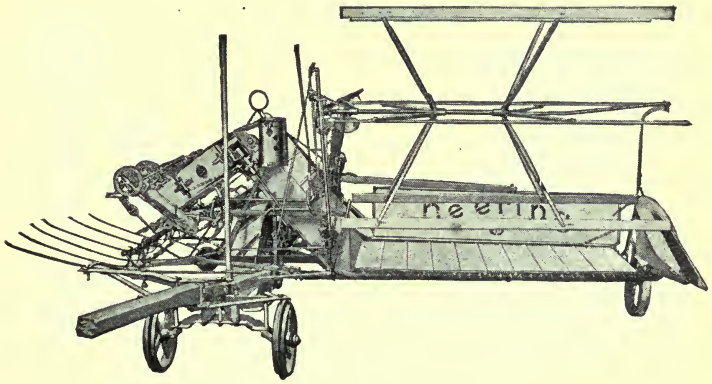

Figure 53—New Ideal binder

figures 55 and 56 illustrate the knotter and twine disk.

Header and Combined Harvester and Thresher. Closely related to the binder is the header and combined harvester and thresher. The header cuts the grain just below the heads and elevates it immediately into a header box drawn by horses alongside of the machine. By cutting the grain high a great many parts of the binder are eliminated and less handling is required.

The combined harvester and thresher is largely used where conditions are such that the grain can be cured while standing. This implement is a combination of the binder

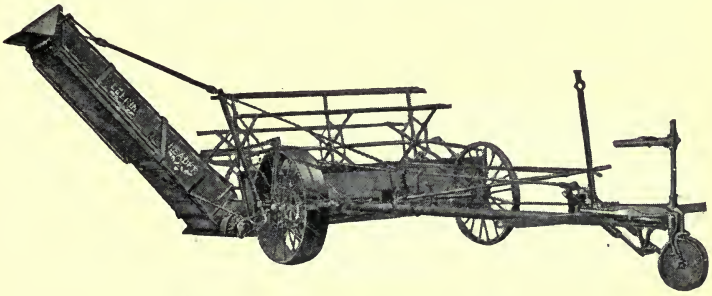

Figure 54.—Combined harvester and header.

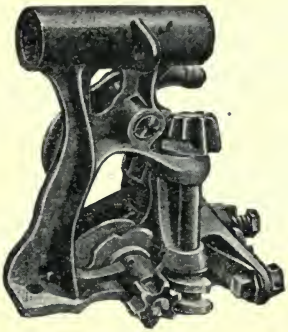

Figure 55.—Knotter.

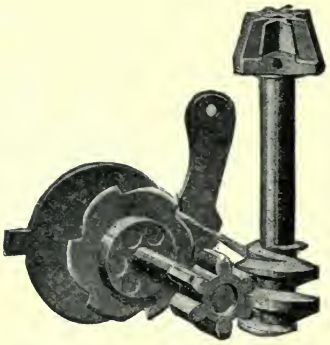

Figure 56.—Steel twine holding disk and pinion.

and threshing machine. It requires from ten to thirty-six horses or a large traction engine to operate one of these machines. The small combined harvester and thresher has been so perfected that two or three men and ten or twelve horses harvest from ten to sixteen acres of grain per day. Better results are had by mounting the stationary gas engine on the harvester to drive the machinery at constant speed and use horses or a tractor to pull the machine.

Haystackers. No piece of machinery is so diversified in make as is the haystacker. Each section of the country has its own peculiar type of stackers. The kind of hay, the dryness of the soil, and location of the haystack, are factors that should determine to a large extent the kind of stacker used. Many of those used to-day are homemade and serve their purpose well. There are, however, some patented stackers that are giving good results. The essential requirement of a good stacker is that it shall be possible to put the hay in any

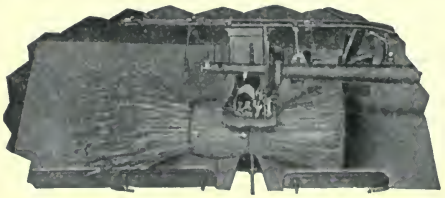

Figure 57.—Binding attachment.

part of the stack in a short interval of time and raise the hay to a height of from twenty to thirty-five feet. The hayfork or nets and wagon with a hay loader are used successfully in case there is a long haul. Where the hay is stacked in the field the sweep rakes and swinging stacker make a good combination. The latter method seems to afford the most rapid method of putting up hay.

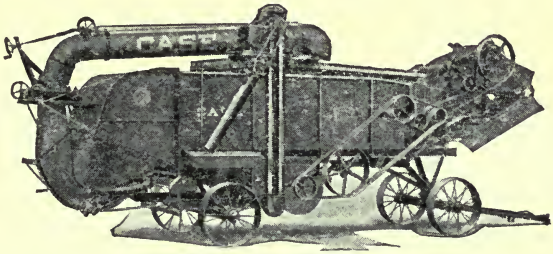

Figure 58.—Threshing machine.

Wagons. The wagon is the most universally used implement on the farm. On account of this fact, perhaps, there are more styles of this implement than any other. The greatest variation exists in the height of wheel and the width of tire. Manufacturers are, therefore, compelled to make a great many sizes of wheels and keep them in stock in the jobbing houses. This condition necessarily increases the cost of the wagon. Better results would be obtained if the farmer would use wider tires. A wagon manufacturer recently made the following comment concerning standardization of wagons: "Wide tires on all wagons will mean better roads, the hauling of heavier loads with less power, less wear and tear on the wagons, team, and equipment, besides saving of time required to market the farmer's product. This matter of time alone is getting to be a tremendous factor to the farmer, owing to the scarcity and the high prices of farm labor."

Beet Digger. The beet digger is used mainly in the digging of sugar beets. As it must run deep enough not to injure the beets, it must be strong and well-made. To avoid breaking the beam a draft rod is provided which is attached directly to the standard. This rod is raised or lowered to

Figure 59.—Good wagon and team.

vary the depth of working. The front of the standard as well as the share should be kept sharp. If they are not sharp, the draft of the implement is greatly increased. The implement most needed in many sections at this time is a successful beet digger and topper. Such an implement would materially decrease the cost of raising beets.

Potato Digger. The potato digger has become a very useful tool where potatoes are grown on a commercial basis. They are often plowed out with a common plow, which leaves them in a poor position for those who pick them up, and many of the potatoes are often covered and left in the field. The digger is very often provided with a vibrating rack which receives the potatoes as they come from the

ground, shakes them free from dirt, and deposits them in a row on the ground. A gauge wheel regulates the depth. In the rear of the gauge wheel is a weed fender used to separate the weeds and vines. Some farmers cut the weeds and vines and remove them from the land before digging is commenced. Another type of potato digger is used where these tubers are grown on a very large scale. This machine digs the potatoes, shakes them clean, and delivers them into a wagon box.

Fanning Mill. To prevent weeds from growing on the land, and to give seeding machinery the greatest efficiency, it is necessary to separate grain mechanically into its several classes. This work can be accomplished very successfully by the use of a fanning mill. The essential feature of a mill consists in feeding the grain to a series of oscillating sieves in the presence of an air blast. The blast of air separates all dust and finer particles from the grain. The sieves with different sized mesh separate the grains into several grades according to their size, shape, and weight. In some instances it may be necessary to use two or three kinds of mills to get the desired results or to pass the grain or parts of it through the same mill two or three times. Too little attention is paid by the average farmer to the possibilities of this machine.

Pumps. Many different types of pumps are used about the farm to-day. Force pumps are especially adapted for domestic purposes. For irrigation purposes, when it is desired to raise a large quantity of water with a small lift, the centrifugal pump is best. The latter type of pump is made with a vertical or horizontal shaft.

Power on the Farm. With the use of modern machinery on the farm has come the introduction of farm motors. The extension of electric power plant lines and the low cost of electric power are making it possible to use electricity for many purposes with profit on the farm. Feed grinders,

Figure 60.—Threshing by power.

water pumps, fanning mills, bone grinders, alfalfa mills, milking machinery, and many other farm machines may be operated by gasoline or electric motors. Much drudgery is eliminated by the use of a small motor, to operate such home devices as the sewing machine, washing machine, wringer, vacuum cleaner, churn, and ice cream freezer. Either gasoline engines or electric motors may be used.

The Automobile. The time has arrived when, under some circumstances, the automobile is a necessity. It is

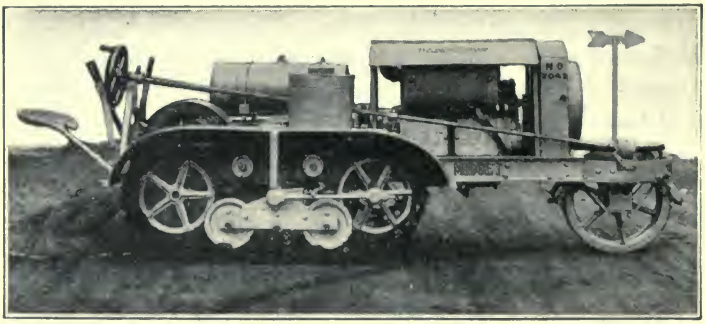

Figure 61.—Caterpillar tractor.

true that in many cases it is a luxury, but in the business world it has come to stay and its abandonment would be a great setback to civilization. It is being used in all phases of agricultural work to-day. The price is such that it is possible for the well-to-do farmer to buy an automobile and

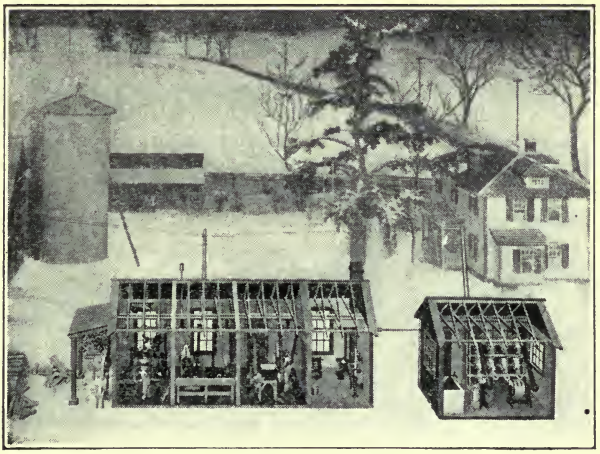

Figure 62.—Farm power plant.

use it to advantage. The automobile is being used a great deal to overcome waste of time and add convenience and comforts to the home.

Care of Farm Machinery. A rather large percentage of the farmer's annual income is spent for machinery to do farm work. Much of this machinery is replaced several years before its real life would justify. In such cases poor care, lack of adjustment, or replacement of parts is invariably the cause. Too many farmers have for their machine shed the open heavens. Sometimes a machine is thrown away and a new one is purchased, when by replacing a few of the worn parts the machine might be made as good as new.

An application of a coat of paint to the wood and stationary metal parts of a machine and a little lubricating oil to

pinions, axles, and levers will often improve the looks and prolong the life of a machine. When a plow is not in use, the polished surfaces should be coated with grease sufficiently hard to insure its not running off; the other parts should be kept well painted.

QUESTIONS

1. How is the dropping of seed in the drill regulated?
2. How wide a swath can be cut with a mower? A binder? What parts of the mower are likely to give way first?
3. How is it possible to cut and thresh grain in one operation?
4. Describe a method of stacking hay.
5. Of what benefit is the fanning mill to the farmer? Enumerate the various steps employed in a fanning operation.
6. What do you consider to be the most beneficial implement on the ordinary farm? Give your reasons.

EXERCISES AND PROJECTS

1. Trace the moving parts in a mowing machine from the large wheel to the knife. How is the motion transmitted? Locate all the bearings to receive oil. Which bearings do you think need the most oil?
2. Make a survey of several farms and find how many of the farmers have housed and cared properly for their machinery. What improvements by way of care could be made?
3. Find a mowing machine out of repair. Locate the trouble and remedy it.
4. Secure a dull mowing machine knife (or sickle) with some sections broken. Remove the broken sections and rivet on good ones. Grind the knife properly.

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CHAPTER XXV

GRAIN CROPS

Grain crops are the principal sources of concentrated food for both man and animal. They were among the first plants to be used by man, and the raising of them has always had an important place in agriculture. Most of the grains are produced by plants of the grass family and are commonly called cereals.

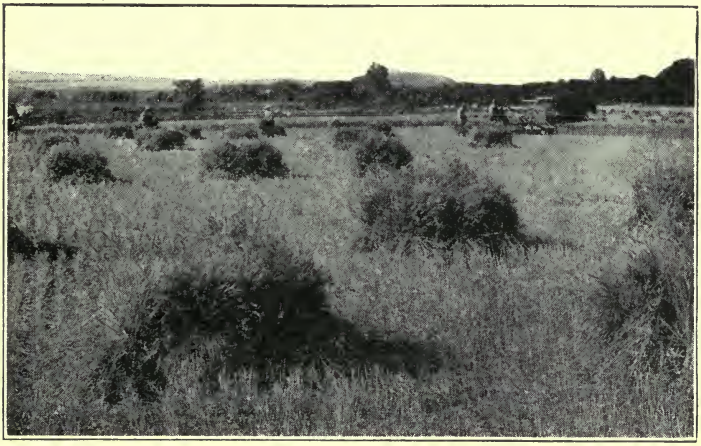

Figure 63.—Wheat harvesting in Kansas.

Wheat has been known since the dawn of history and has always been a favorite food for man. Flour made from wheat gives a lighter bread than that made from any of the other grains. Wheat is raised in nearly all parts of the world, but the United States and Russia produce much more than any of the other countries. India, France, Austria-Hungary, Italy, Canada, Germany, Argentine, and Spain also contribute much toward the world's supply, which is

about three and a half billion bushels a year. Every month in the year wheat is harvested in some country.

Wheat grows best on a rather heavy soil and is adapted to a cooler climate than corn. While it yields heaviest with a good supply of moisture, the best quality of grain is produced under drier conditions. The most valuable constituent of wheat is gluten, which decreases with the increase of moisture during growth.

There are at least 1,000 varieties of wheat known; but only about 250 of these have any importance. These varieties are grouped into eight types. Certain varieties are adapted to spring planting; others to fall planting. There are hard and soft varieties, hardness being caused partly by variety characteristics and partly by climate. Hard wheats have a high nitrogen content.

No one variety is best for all conditions. Each farmer should find the variety best adapted to his farm. From one to two bushels of seed are usually planted to the acre, preferably with a drill on land that has been thoroughly prepared. The seed should be previously treated for smut.

The kernel of wheat is made up of several distinct layers, but there are three principal parts: the outer layer from which bran is made; the inner, white portion which makes flour; and the inner, yellow portion at one end of which is the germ. It is from this germ, or embryo, that the young plant starts growing. Graham flour is made by grinding the whole kernel, while certain parts are sifted out to make the various grades of white flour. The by-products of milling, such as bran, are used almost entirely as stock feed.

Corn, first grown in America, was found by the Europeans when America was discovered. It was used extensively by the Indians as a food and is still highly prized for this purpose by the native American races. It is not raised over nearly so wide an area as wheat,—more than three fourths of the entire crop of the world being produced

in the United States, and more than half of the corn in the United States being raised in 1912 in the following eight states, which are arranged according to the amount produced: Illinois, Iowa, Missouri, Indiana, Nebraska, Kansas,

Figure 61.—Corn under irrigation.

Ohio, and Texas. In this country there are about four times as many bushels of corn produced as wheat, which amount would be over 30 bushels for every person in the country.

Corn is very sensitive to temperature changes and needs hot weather during its growing season. Cold nights during this time greatly reduce the yield. Unlike the smaller cereals this crop requires much labor during the growing period, as it is greatly benefited by continued cultivation. It responds more than most crops to liberal applications of stable manure,

and in a rotation is suited to follow crops leaving a sod.

Corn may be classed in six groups: (1) pod corn, (2) pop corn, (3) flint corn, (4) dent corn, (5) soft, or flour, corn, and (6) sweet corn. Of these, the dent and flint are most important, while the pod corn has no economic value. These various types have kernels of very different structure and composition. The dent corn is the type most widely grown in the corn belt, although the flint is also important. The yielding power and quality of corn have been greatly modified by breeding, and special-purpose corn is now common. The length of the growing season of each district is an important factor in selecting the variety to plant.

Figure 65.—Loose smut of oats.

The time for planting corn is later than for the small grains. Young corn plants are injured by frost, hence planting should be delayed till the danger of frost has passed. About a peck of seed is required to plant an acre.

Corn is used mainly as a feed for live stock, as it is a good fattening ration. The entire plant is often harvested just before it is ripe and cut up for silage. Many important manufactured products are also made from this crop.

Seed corn must be selected and stored with great care. The best ears should be taken from the best plants while standing and then stored where they will keep dry, as the germinating power of the kernels is greatly reduced by moisture.

Oats. The oat is one of the most useful and widely known of the cereals. More than one half of the world's

supply of this crop is raised in Europe, but the United States produces more than any other country. Iowa and Illinois are the two great oat-producing states of the Union. There are more bushels of oats raised in the world each year than wheat, although the money value is not so large.

The oat plant is more fit to grow in cold climates than either wheat or corn, and it requires a moist soil. A shortage of water will greatly reduce its yield. On the other hand, poor soils may produce good crops. About 150 varieties of oats are known; only a few are suited for fall planting.

The kernel of the oat is enclosed in a hull which is not removed on threshing. This grain is prized very highly as a horse feed. It is also used in making oatmeal. In some countries this forms a large part of the diet of the people. The grain varies greatly in weight to the bushel and in composition, according to the amount of hull; hence, it is safer to buy it by weight than by measure.

The preparation of the seed bed for oats is the same as for the other grains. The depth of planting varies from one to four inches, depending on the nature of the soil and the amount of moisture present. Oats should be planted early in the spring in quantities of from five to eight pecks under ordinary conditions. The seed should first be treated for smut.

Oats are often raised for hay, in which case they are cut before ripe and handled like other hay crops. They make a palatable and nutritious forage. Even when oats are allowed to ripen and are harvested for grain the straw makes a good roughage for stock.

Barley is raised over a wider range of climate than any other cereal. It is found from the North, where the soil thaws but a few inches in the summer time, to the South, where the climate is semitropical. While not sensitive to temperature, barley is more exacting than most of the cereals in regard to the condition of the soil. It requires a well drained soil rather light in texture, and responds readily

to proper preparation of the seed bed. In the rotation it does well after a hoed crop. The time and method of seeding are similar to those for oats. About two bushels of seed are ordinarily planted to the acre.

A B C D E

Figure 66.—Types of barley heads. A—Side view of head of new awnless barley. B—Separate grains and spikelets of the same. C—Front view of the head of same. D—Separate grains and spikelet of hooded barley. E—Head of hooded barley.

Barley is grown almost entirely for malting and stock feed. A high starch content, desired for malting, is not so desirable when the grain is fed. In raising this crop the variety should be suited to the use for which it is intended. For fattening live stock barley is hardly equal to corn, but for producing animal growth is perhaps the best cereal.

The common varieties when threshed retain the hull, but there are a number of hull-less, or bald types. There are both spring and fall varieties.

Rye is sometimes called a poverty crop, doubtless on account of its ability to grow on soils that are too poor to produce other cereals. Notwithstanding this characteristic, it responds readily to a good soil and proper treatment.

Rye is fifth in importance among the cereals of the United States. It is the chief grain raised in Russia where more than one half the crop of the world is grown. In Europe it is used largely for flour, while in this country it is fed to stock. A third use is the making of alcoholic drinks. The

Figure 67.—Kaoliang on a dry-farm.

straw is too tough to make good feed, but it often brings a good price for weaving and packing and for stuffing horse collars. Unlike the other cereals, but few varieties of this crop are known; it is usually classified simply as winter and spring rye. The winter type is as a rule the heavier producer and is often used as a fall and winter pasture.

Rye produces a long, slender straw, which is so strong that it seldom lodges. This habit of growth, together with the fact that it matures early, makes it a favorite nurse crop in many localities. Rye is seldom an entire failure, although it never yields heavily.

The methods of culture of rye are similar to those of the other small grains. Five or six pecks of seed to the acre are planted. It has few enemies, the worst being ergot, a disease of the grain, which renders it unfit for man or beast.

Emmer is closely related to wheat. A striking difference in appearance, however, is that the emmer contains a hull around the kernel which is not removed by threshing. This crop has been raised since the dawn of history, but it has not been grown so extensively on the western hemisphere as some of the other cereals.

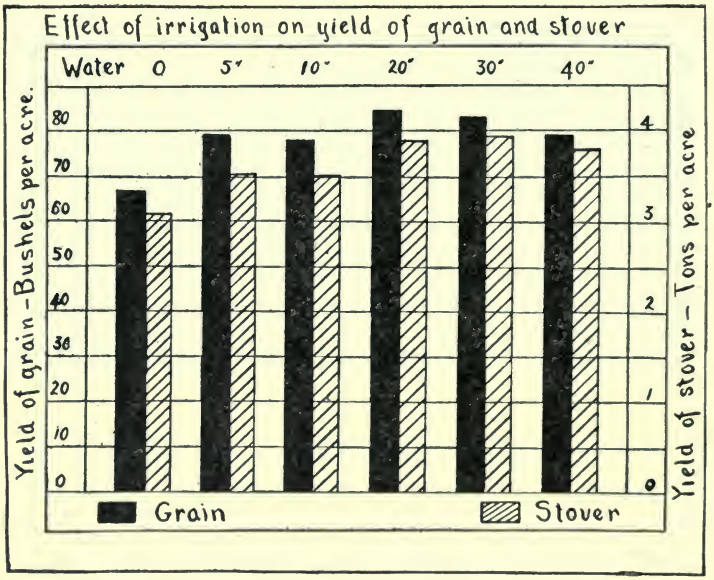

Figure 68.—Effect of irrigation on yield of grain and stover.

Drought resistance is claimed as one of its most valuable characteristics and it will doubtless gain a place as a crop for arid regions. Its methods of culture are similar to those of wheat, and its use is chiefly as a feed for live stock.

The grain sorghums include a number of crops which, when young, resemble corn, but which produce their grain in the head corresponding to the tassel of the corn. These crops have been introduced from the arid parts of the old world and are now grown extensively in the southern

portion of the Great Plains and to a less extent in other arid sections of the country. These grains are used principally for stock, especially for chicken feed. In some sections they are ground for human food. Drought resistance and heavy yielding power recommend them to the dry-farmer.

Buckwheat is a grain produced for its flour, which is used extensively in making the well-known buckwheat cakes. It is raised in only a few states, New York and Pennsylvania producing two thirds of the nation's crop. Unlike most of the other grains, buckwheat does not belong to the grass family, but to a group of plants quite different in form and manner of growth.

Rice is eaten by more than one half of the human family. It is the chief food of many of the peoples of Asia. The plant is more nearly related to corn and the sorghums than to the other cereals.

SCORE CARDS

Wheat

	Points
Uniformity	
(a) Color	10
(b) Size of kernel	5
Purity	
(a) Trueness to type and variety	10
(b) Freedom from foreign matter	10
Condition of grain	
(a) Freedom from must and smut	15
(b) Freedom from broken kernels	5
Hardness and Texture	20
Weight per bushel	25
	100

Oats

Color (uniform, bright)	10
Freedom from must and smut	15
Freedom from foreign matter	10
Freedom from injured kernels	10
Size of kernels	5
Weight per bushel	50
	100

Corn

Uniformity of lot	10
Color (uniform, bright)	10
Maturity	25
Freedom from molds and excessive moisture	10
Freedom from smut, insect, and other injury	10
Size and shape of ear, row, kernel	10
Quantity	
(a) Percentage of grain to cob	10
(b) Fullness of butts and tips	5
(c) Depth and closeness of kernels	5
Texture	5
	100

Barley

Color (uniform, bright)	25
Freedom from odors, must, etc.	25
Freedom from foreign matter	10
Freedom from injured kernels	10
Texture	15
Weight per bushel	15
	100

QUESTIONS

1. Where is most of the wheat of the world produced?
2. What special qualities of wheat make it desirable for bread?
3. Under what conditions does wheat grow best?
4. What are the main parts of a wheat kernel?
5. What conditions are required for the best growth of corn?
6. What are the classes of corn? Describe each.
7. Give directions for getting good seed corn.
8. What are the chief uses of corn?
9. Under what conditions do oats thrive best?
10. Give the chief uses of oats.
11. How does barley compare with the other grains in adaptation to climate?
12. How does barley compare with corn as a stock feed?
13. Under what conditions would it pay to raise rye?
14. To what conditions are grain sorghums suited?

EXERCISES AND PROJECTS

1. Take a wood block. With an auger bore holes in it a half inch deep. Cover with pasteboard having holes in it. Make a col-

lection of various grains. Place some of each in a hole. Label. Cover with glass and preserve.

Another method is to put the samples in small bottles and label. The bottles may be stood in holes in heavy pasteboard which is raised an inch or so above the bottom of the box by turning down the ends of the pasteboard, after which it should fit the box closely.

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CHAPTER XXVI

FORAGE CROPS

ALFALFA

Alfalfa, or lucern, has been used as a forage since the dawn of history. It was brought to America by the early settlers but attracted little attention until about fifty years ago when its growth in the West became important.

Figure 69.—Alfalfa in rows on a dry-farm.

The alfalfa plant belongs to the family of legumes, which, through the growth of nodule-forming bacteria on their roots, are able to fix nitrogen from the air and thereby help maintain the fertility of the soil. It grows from year to year without reseeding and produces from two to six crops of forage each season, according to the length of the growing period. Its roots grow very deep and are thus able to draw water and food from a large area. In the United States most of the alfalfa is raised in the western states, although

it is being introduced into the East very rapidly. It is raised all over the world, especially in South America.

Alfalfa is naturally adapted to a warm climate, although some strains are successfully grown where it is rather cold. It requires a well-drained soil; a high lime content also favors growth. Like other legumes, it thrives only in soil containing the kind of bacteria suited to grow on its roots to help

Figure 70.—A good field of alfalfa.

in supplying it with nitrogen. Some soils have to be artificially inoculated with the germ before they are suitable for the growth of alfalfa. This inoculation is sometimes done by adding pure cultures of the bacteria to the seed or soil, but it is usually better to get soil from an old alfalfa field which is known to be inoculated and spread this over the new field at the rate of at least 100 pounds to the acre.

The seed may be planted any time from April to October, but it is usually thought that April is the best time with August or September as the next best. The quantity of seed to be used will depend on the soil and climate. Deep, fertile soils in moderate climates with good rainfall can develop more seed than poor soils in dry and cold or hot

regions. The quantity used varies from five to thirty pounds to the acre. The greatest care should be taken to prepare the land properly, in order to get a good, even stand, since one seeding serves for a number of years. In planting alfalfa it is sometimes advisable to sow the seed with a nurse crop like barley, wheat, or rye. This method enables the farmer to get a crop of grain during the first year while the alfalfa is establishing itself.

In the dry lands of the West, the raising of alfalfa seed is very profitable where conditions are favorable. Seed production usually requires different conditions from those necessary to raise the best forage.

As a feed for live stock, alfalfa is unsurpassed. There is no crop which stock relish more or which has a higher nutritive value.

THE CLOVERS

The clovers are closely related to alfalfa. They are grown in nearly all parts of the United States, over a great part of which they are the chief legume crop. They are much better known in the eastern states than is alfalfa, while in the western states the opposite is the case.

The clovers are suited to grow with the grasses and fit well into crop rotations. As a rule they do not yield so many tons to the acre as alfalfa; and clover hay is not usually regarded as equal to alfalfa in feeding value. Many different clovers are known, but only a few are important.

Red clover is raised in all parts of the country. It is the best known and most useful of all the clovers. There are two varieties: the common, or medium, and the mammoth. Except for size these look alike and their seeds cannot be distinguished. The medium matures considerably earlier than the mammoth which matures at the same time as timothy. This earlier maturity is quite an advantage in hay making. Red clover requires a good, well-drained soil. It

may produce two cuttings in a season, if the first cutting is made early. By the time the crop grows two years most of it is usually killed by the root borer and it needs to be reseeded. It is a good crop to sow in all meadow and pasture mixtures for re-establishing fertility of soil.

Alsike clover is much like the red in many respects. Its flowers are pink instead of red, and the pattern of its leaf is different. It is adapted to grow on heavy soil, although it will grow on almost any soil that is sufficiently wet. It is better suited to the northern than to the southern part of the country. It can be grown as a hay crop either alone or mixed with grasses, and should always be included in a pasture or meadow mixture that is to be sown on low, wet lands.

White clover is much smaller than the kinds already mentioned. It rarely produces enough forage to be raised profitably alone, but it is a good plan to include it in mixtures for pastures and lawns, as it readily fills in space not occupied by other plants. It grows close to the ground, forming a good turf.

Crimson clover is an important crop in some parts of the South, but it is not suited to cold climates. In regions adapted to its growth it makes a good crop for orchards. It is an annual plant and prefers sandy soils. An abundance of hairs, which may form balls in the stomachs of horses, greatly lessens its feeding value.

Sweet clover is a strong vigorous growing biennial. It is a very hardy plant producing rather heavy stems which, coupled with its strong odor and bitter taste, cause it to be less palatable for live stock than clovers and alfalfa. It must, therefore, be cut young when cured for hay. It is often regarded as a weed, because it grows by ditch banks and because it is difficult to eradicate. If kept from producing seed, however, it can soon be killed out. It is a good plant to resist alkali and has promise as pasture or as

a green-manuring crop in alkali districts. Its use as a hay crop is increasing rapidly.

OTHER LEGUMES

Field peas begin growth in an upright position, but as the plants get older they trail on the ground. This trailing habit makes the crop unsuitable for pasture, and also makes desirable a companion crop to serve as a support. Oats are often used for this purpose. The two crops grown together make a first-class forage. They are especially suited to be used in a soiling system in cool, moist areas, such as the high mountain valleys of the West.

The cowpea is a leguminous plant which is increasing very rapidly in agricultural importance. In the South it occupies much the same place that clover holds farther north. In form it resembles the bean more than the pea. It is often raised with corn, being planted between rows when the corn is cultivated the last time. Ordinarily the cowpea does not receive much cultivation, although it responds well to it. One of its principal uses is as a green manure.

The soy bean is an upright, rather woody annual, growing three and sometimes four feet high. In many respects it resembles the cowpea. Their places of growth and uses are similar. In the Orient the soy bean is used very extensively. It should receive more attention in many parts of this country, as it is used both for its seed and as forage. It has great promise as a source of oil.

Vetch. Two types of vetch are commonly raised, the winter, or hairy, vetch and spring vetch. The vetches are used extensively as green manures and are usually grown with other crops. Rye and vetch go well together and when properly handled make a good forage.

THE GRASSES

Grass covers great areas of land. It is used to fill in where other crops are not raised. Nothwithstanding its

great importance but little study is given to it in comparison with other crops. Too often the land sown to grass is given no attention aside from that neccessary to harvest the crop. The grasses are crop plants and should be treated as such by being given the culture they merit.

Varieties should be selected to suit the locality in which they are to be raised, and the land should be properly prepared. Care should be taken in buying grass seed, as it is

Figure 71—Hay in the West.

often very much adulterated with weed seeds and is often low in germinating power.

In the West, where alfalfa is grown so extensively, farmers have not become so well acquainted with the value of the grasses and know little of the methods of handling them.

Timothy is the best known grass and the most important hay-producing plant in America. It does best in the northeastern portion of the United States, but is grown to some extent in almost all parts of the country. It is adapted to a cool climate and a rather heavy, moist soil. It is an easy crop to start and its seed is cheap. It usually produces better for the first few years after seeding than later. Horses relish the hay, which always brings a high price. It is

often taken as the standard which sets the price of other hay. It is decidedly inferior to alfalfa as a cow feed, and it would often pay the farmer to sell his timothy and buy some leguminous hay. Fields raising timothy should not be allowed to remain many years without being plowed and planted to something else. Its sod, when plowed under, leaves the soil in good condition for the next crop, especially if clover was mixed with it.

Kentucky blue grass is raised in nearly all parts of the country, although it does not do so well in the hotter parts of the South. It is much more important as a pasture than as a hay grass. It is, however, cured in some districts. Canada blue grass is much like the Kentucky, although inferior in producing power. It will, however, grow on poorer land. Its seed is often found as an adulterant in the more expensive Kentucky blue grass seed.

Figure 72.—Millet under irrigation.

Orchard grass is a tall, tufted grass adapted to grow in deep rich soils. It produces a coarse forage which makes a good feed if cut when blossoming begins, but if left longer the hay is tough. It starts early in the spring, and is, as a result, a good crop to include in a pasture mixture. As its name indicates, it grows well in the shade of trees.

Smooth brome grass was introduced from Russia. It is one of the most valuable grasses for the arid regions. It starts early in the spring and grows late in the fall. The hay is liked by cattle, horses, and sheep. It is suited both for pasture and hay production. On account of its strongly

stoloniferous habit it is likely to become "root bound" in a few years and consequently should not be raised too long in one place without plowing. In planting this grass about twenty pounds of seed to the acre is required.

Redtop is one of the most important of the hay grasses, though not so popular as timothy, on account of its being unpalatable. It is adapted to growth on wet soils and gives a fair yield on poor soils.

The millets are summer-growing crops, requiring considerable heat and maturing in a short time. In this country they are used almost entirely as a forage crop, but in Asia they have been raised for ages as a grain for human food. There is a number of distinct types of millet.

QUESTIONS

1. What is a legume?
2. Name some conditions required for the best growth of alfalfa.
3. How does alfalfa compare with the grasses as a feed for stock?
4. Give the conditions under which the different clovers thrive best.
5. Under what conditions can field peas be raised to advantage?
6. Compare cowpeas, soy beans, and vetch.
7. Compare the relative merits of timothy, blue grass, orchard grass, redtop, and brome grass.
8. What other kinds of grass are raised in your vicinity?
9. What are the millets used for?

EXERCISES AND PROJECTS

1. Make a collection of forage plants.
2. Collect pictures of haying methods.
3. Measure a haystack and compute the tons of hay in it. This is done by measuring the width of the stack, the length, and the overcast. The overcast is the distance straight over the stack from the ground on one side to a corresponding point on the ground on the other side.

$$\frac{\text{Overcast} \times \text{Width} \times \text{Length}}{4} = \text{cu. ft. in stack.}$$

Divide this by 450 (if hay has been long stacked; if not, 500 cu. ft.) to find the number of tons. The formula is expressed thus:

$$\frac{O \times W \times L}{4} \div 450 = \text{tons}$$

4. Dig up an alfalfa plant to the depth of a foot. Dig carefully so as to preserve the small roots, especially those near the surface. Note the small enlargements about the size of a pinhead. These are nodules in which the bacteria live.

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CHAPTER XXVII

SUGAR BEETS AND OTHER ROOT CROPS

The root crops are of very great importance to the agriculture of the world, both as a direct food for man and as a means of sustenance for domestic animals. These crops are especially valuable on account of their large yield and their succulence, or large percentage of water. The whole agriculture of England was improved in the 17th century by the extensive introduction of root crops, and to-day England is noted for the use of roots in feeding stock.

Figure 73.—A good type of sugar beets.

SUGAR BEETS

The sugar beet belongs to a group of biennial plants which store up food in their roots during one season and use this stored material in the production of seed the next year. The economic value of these plants depends on the use of this stored material.

History. Beets have been used for making sugar on a commercial scale only a little over a hundred years, the first factory being built in Silesia in 1805. Germany and France were the first countries to give the industry great prominence. Sugar beet raising in the United States has been developed almost entirely in the last two or three decades.

Production. Germany and Russia have raised about as many sugar beets as the rest of the world together. In 1910 the world produced eight and one half million tons of sugar from beets, while the United States produced but one half a million tons. Michigan, Colorado, California, and Utah

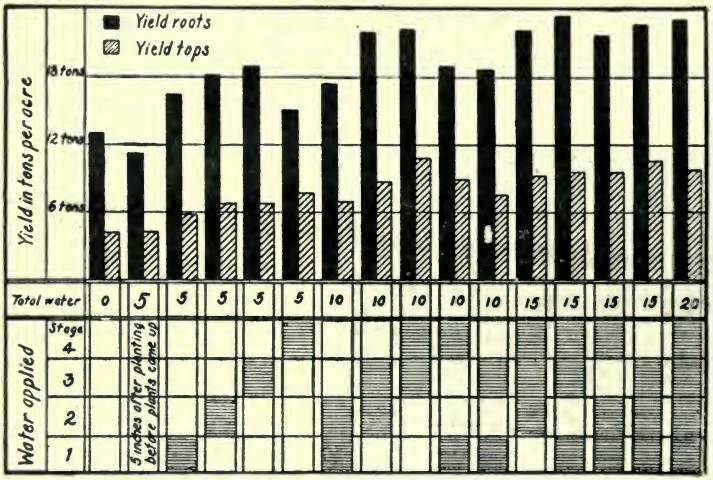

Figure 74.—Yield of beet roots and tops on plants receiving various quantities of irrigation water at different stages. Average for five years.

are our chief producers of sugar beets. Utah leads in the number of tons of beets raised to the acre, having produced 14.54 tons, as a ten years' average, while the average for the whole country was but 9.71 tons.

Condition of Growth. Sugar beets require a rather cool climate, but need a large amount of sunshine for the production of sugar. They flourish in a moist soil, but can not endure water-logged land. They are able to stand more alkali than most crops. Beet land should be given a good dressing of barnyard manure every few years. Greater care needs to be taken to get the soil in good condition than is necessary with the cereals. It should be plowed deeply in

the fall. In the spring the land should be thoroughly tilled and made as mellow as possible.

Seeding. Planting is done early in the spring, usually earlier than corn. About twenty pounds of seed to the acre are sown, although this amount varies somewhat with conditions. The rows are usually about twenty inches apart, but are sometimes as close as eleven or as far apart as twenty-seven inches. By placing the rows closer together larger

Figure 75.—A high yielding sugar beet field.

yields to the acre are secured, but less for the labor involved; and labor is a very important item in raising sugar beets.

Thinning. When the plants have about four leaves they have to be thinned. A block is chopped out with a hoe, leaving little bunches from eight to twelve inches apart. Each bunch must then be thinned by hand, leaving but one plant in a place, in order that the beets may have the proper space. Thinning is the most tedious and expensive operation in beet growing.

Cultivation. During the growing season beets require considerable cultivation. There is at present good machinery on the market with which to do this work. Shallow cultivation should begin when the plants are small.

Irrigation. If watered too much the beets grow so large and the sugar content is so low that the factories are compelled to refuse them. The best kind of irrigation will give the beets a regular supply of moisture during growth and allow them to ripen properly. An irrigation just before harvest may be undesirable. Water too early in the season is also objectionable.

Figure 76.—Beets piled in the field. The tops are also saved.

Harvesting. The ripening of beets is indicated by the withering of the leaves, which usually occurs about the middle of October. Beets will stand some frost, but are better if not subjected to severe freezing. They should, therefore, be dug as soon after they are ripe as convenient. There is a number of implements for digging the beets. The one to use depends largely on the kind of soil.

Uses. Sugar beets are used largely for the manufacture of sugar, but on account of their succulence they also make a good feed for live stock. By-products of sugar making, such as pulp and molasses, are used extensively as feed.

Seed. The successful making of sugar from beets depends on their containing a high content of sugar. This

has been obtained by many years of careful selection, and, in order to maintain it, continued selection is necessary. Great care must, therefore, be exercised in producing the seed. Until the last few years practically all the seed used

Figure 77.—Pedigree sugar beet seed at Utah Experiment Station.

in the United States was imported from Europe, but now much is produced in a number of the western states.

Rotation. Sugar beets are well adapted to enter into a crop rotation. They occupy about the same place in the rotation as potatoes or corn. On account of their deep rooting, beets leave the soil in good condition for the crop that follows. This is especially true if manure has been applied to the land before planting. It is a mistake to plant land continuously to beets simply because they pay. The results of a proper rotation are much better.

Importance. In regions where sugar beets can be profitably produced the whole agriculture of the region is

improved by raising them. They teach better methods of tillage and thus add to the producing power of the soil. They make a crop which the farmer can sell for cash at a price he can depend on.

OTHER ROOTS

Mangel-wurzels are grown extensively as a stock feed. Their habit of growth is similar to that of sugar beets, but differs in that a considerable part of the mangel grows out of the ground. Mangel-wurzels can withstand drought better than the other root crops. The method of preparing the land for this crop is similar to that for sugar beets. From six to eight pounds of seed are sown to the acre. In feeding value, they are about equal to sugar beets, but they have less sugar and dry matter.

Turnips and rutabagas are grown extensively in some sections of the country. The preparation of the soil and the cultivation, harvesting, and storing of these crops is similar to that for mangel-wurzels. They do best on a sandy soil. Four pounds of rutabaga and three pounds of turnip seed are usually sown per acre. Early seeding is desirable. The yields of these crops are as a rule less than for mangel-wurzels. In Canada, turnips and rutabagas are the chief root crops for stock feeding.

Carrots have a wider climatic adaptation than mangel-wurzels and rutabagas and do best in a deep, sandy loam. It is customary to sow about six pounds of seed to the acre, although with good seed and seed bed less may be used. Difficulty is often experienced in getting a good stand of carrots; consequently there should be great care in planting. The yield is from ten to thirty tons to the acre, with the percentage of dry matter higher than for other root crops except sugar beets. Carrots are especially good for horses and also form an important human food.

QUESTIONS

1. What place do root crops have on the ordinary farm?
2. Give the history of the beet sugar industry.
3. Under what conditions do sugar beets grow best?
4. Give directions for handling a crop of sugar beets.
5. Why is thinning of beets necessary?
6. Compare mangel-wurzels, turnips, rutabagas, and carrots as regards methods of handling and uses.

EXERCISES AND PROJECTS

1. Make a collection of the various root crops, label and preserve.
2. Collect a sackful of some root crop—sugar beets, mangels, carrots, or turnips. Select out the medium-sized, smooth ones. These are the most desirable. Place those irregularly shaped in one pile; those very large and very small in another; and those bruised, broken, or otherwise injured in another. The last three piles are undesirable.

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CHAPTER XXVIII

POTATOES

The potato is a native of America. The Spanish conquerors of Peru introduced it into Spain and Portugal sometime during the middle part of the sixteenth century. From there it spread into Italy, and later to other parts of Europe. Spanish voyagers carried it to Virginia whence it was taken to England at the time of Sir Walter Raleigh's voyages. From England potato culture spread rapidly into Ireland, where, at the beginning of the eighteenth century, the crop had become common. Its almost universal use in Ireland since that time has given it the common name of Irish potato. Ireland still leads in the use of the potato with an annual per capita consumption of twenty-five bushels, about seven times that of the United States.

The potato plant is an annual, which in its wild state is reproduced freely by seeds. The tubers are very small and woody. The cultivated potato rarely seeds, the plant having become perennial through its tubers. The main vertical underground stem varies in length with the depth of the planting. This stem produces branches, the ends of which enlarge and form tubers. Usually from two to four roots start from the base of each tuber-forming branch. Three or four inches below the surface of the soil the roots extend for about eighteen inches horizontally and then turn and go downward, penetrating from one to five feet.

The tuber is not a seed, but a swollen, underground stem with its eyes equivalent to the leaf buds on a tree. It is simply a branch in which the plant stores food.

When a potato is cut in halves, four layers may be seen. Beginning at the outside, the first is the external cortical,

which is poor in starch; next is the internal cortical, rich in starch; then, the external medullary, also rich in starch; and, finally, in the center the internal medullary, very poor in starch. A potato to have good cooking quality should have proportionately large cortical and external medullary and small internal medullary.

The Potato Wanted. The market demands a medium-sized potato, between two and four inches in diameter, and weighing from one half to one pound.

The flat-round or oval shapes with shallow eyes are in greatest demand; they are of better quality and waste less in peeling. White, or yellowish-white, skin, and white, fine, firm-textured flesh are preferred except in the South where red is favored. Thick-skinned varieties are usually preferred, because they can be handled with less danger of being bruised or otherwise injured.

Good quality in potatoes is indicated by the tuber's becoming mealy when cooked. This mealiness is due to the separating of cells or to the breaking of the cell-walls, causing the starch grains inside to mingle together in a mass. If, however, the cell-walls do not burst, but can be easily mashed by applying slight pressure (as with a table fork), the quality may be regarded as medium. In case the potato remains solid, heavy, and watery after being cooked, the quality is poor. Where potatoes are planted so deep that the change of temperature between night and day does not affect them, and where constant favorable moisture can be maintained, the quality will probably be good, because the even temperature favors the development of starch. Where potatoes are planted shallow and developed near the surface of the ground, the change of temperature between night and day injures the quality. Exposure to light injures the quality by causing the potatoes to turn green.

Seed Bed. Potatoes do best in light soils such as deep, friable loams and sandy loams. The seed bed should be

well-prepared, because the growing tubers exert a considerable pressure in every direction, and, if the seed bed is lumpy and rough, they will become knotty and irregular. As soon as possible in the spring it should be thoroughly harrowed to conserve the moisture, and also to bring weed seeds near the surface of the ground where they will germinate. Just before the potatoes are to be planted the ground should be harrowed again to kill the growing weeds.

Seed. If small, poor tubers be planted, the tendency will be toward the production of a larger number of small potatoes than if tubers of the size and shape desired be planted. The proper way to select tubers for planting, if at all possible, is to make an inspection of the individual hills as they are growing in the field, putting a stake by each hill which has a good, healthful, upright top with a large proportion of leaves to stems. When the time comes to harvest, these selected hills should be dug by hand and the ones containing the greatest number of best sized and best shaped tubers should be saved for seed. They should be stored and planted by themselves the following spring. From them enough will probably be secured to plant the patch. Selection ought to be made in this way each year.

Before cutting, the seed potatoes ought to be soaked two hours in corrosive sublimate 2 oz. to each 15 gallons of water or in formalin 1 pint to 25 or 30 gallons of water.

Cutting Seed. The seed potatoes should be planted soon after they are cut; since, if the cut pieces be allowed to dry out before planting, the plants will be weak and slow in coming up. Quarters and two-eye pieces are probably the best sizes of sets. If cut into two-eye pieces, care should be taken that the eyes are strong, that is, prominent. The eye of the potato need not be deep, but should be well defined. A shallow, poorly defined eye is regarded as low in vitality.

The average acre yield in the intermountain region is around 140 bushels, whereas that of the whole United States is

about 93 bushels. Central Europe has an average of nearly 200 bushels, due to a particularly favorable climate and to great care in seed selection and treatment.

Planting. A machine planter is economical for large acreages; but, when only small patches are grown, hand

Figure 78.—A potato planter at work.

planting is the most practical way. The furrows for planting should be made while the seed potatoes are drying after being treated for disease. Straight furrows are opened with a shovel plow, the potatoes dropped as soon as possible, and covered with moist soil. Covering may be done with a leveler, followed by a harrow. Potatoes should be planted in rows three feet apart and from twelve to eighteen inches apart in the row.

The depth of planting will depend on soil, moisture, and cultural methods. The new tubers should develop where they can get sufficient air and moisture to make a maximum development. In a light soil, this depth will probably be between four and seven inches while on a heavier soil it may be between three and five inches. Deep planting produces

better quality and a larger percentage of marketable potatoes. Planting should be deeper in dry than in wet soils, and in loose than in compact ones.

Cultivation. After the potatoes are planted the land should be thoroughly harrowed, and again when they are just coming up, and after storms large enough to cause the soil to crust. Harrowing ought to be discontinued as soon as the harrow injures the vines. Tillage may be continued with a small-toothed cultivator, running at a depth of from two to four inches. As a rule, the first cultivation should be somewhat deep, whereas the later ones should be rather shallow to avoid injuring the roots, disturbing the tubers, and hilling the vines too much.

Irrigation. Where the seed bed has been properly prepared and the cultivation thoroughly done, it will in most cases not be necessary to irrigate until after the vines have blossomed. They should be ridged up slightly, and every alternate row irrigated. At the next irrigation the other half of rows should be furrowed out and water applied to these. During all other irrigations, run the water through all the rows, cultivating as soon after each irrigation as the soil will permit. If the plants will not go without water until after blossoming, it is well to irrigate earlier. If the soil is heavy and clayey, the irrigation furrows should be deep; otherwise shallow furrows are best.

Too much water has a tendency to lower the vitality and quality of the potatoes. Probably from fifteen to twenty-five inches will give the maximum yield. The aim in irrigating should be to keep the soil at nearly an even temperature and with nearly the same moisture content throughout the growing period. These conditions encourage continuous starch formation.

Harvesting. The usual method of digging, when small areas are grown, is to turn out the potatoes with a plow. When large areas are handled, the potato digger should be

used. If the ground has been properly cultivated, the labor at the time of digging is little, although on land that is foul with weeds or that is cracked and baked it will be great.

Figure 79.—A potato harvesting scene.

Prices and markets have varied so much in the last forty years that farmers could not estimate closely at planting time what their returns at harvest were likely to be. This uncertainty led to much speculative planting. When prices were high large acreages were planted. The markets were glutted the next fall and havoc was wrought with

prices. Sometimes no market could be found, thousands of bushels rotting in the pits or being dumped on waste land. A company in Colorado hit on a scheme of growing the same area each season, carefully sorting the potatoes, and marketing in large quantities. This plan helped materially.

Storing. Potatoes not marketed soon after harvesting must be stored in some cool, dark, well-ventilated place. The ordinary cellar on the farm will usually do for this purpose, provided it is dry. A good pit in which the temperature can be held comparatively low and constant is also good. The following method of storing potatoes is practiced by some of the most successful potato growers:

They dig a pit about one foot in depth, four feet in width, and of any length desired. This is left open until it cools down nearly to freezing temperature. The potatoes to be stored are then put into the pit, nicely rounded up, and covered with a layer of from eight to twelve inches of straw (wheat or rye preferred), over which is thrown three or four inches of earth. Stovepipes or wooden troughs, closed with a roll of cloth in cold weather, should be inserted at intervals as ventilators. The layer of earth is allowed to freeze, and then more straw and earth are added.

Potatoes have been kept in this manner until the middle of April, and, when taken out, were in fine condition for marketing or planting; but cellars are usually safer than pits.

Varieties. The importance of growing only one or two of the most thoroughly tested varieties cannot be too strongly emphasized. The variety selected should yield well, should be acclimated, have disease resistance, be vigorous, and be the kind of potato which markets demand. The following varieties have all done well in the intermountain region:

Early	*Late*	
Early Eureka	Freeman	Pearl
Early Ohio	Majestic	Peachblow
Early Rose	Idaho Rural	Netted Gem
Early Russet	Peerless	Market Prize

QUESTIONS

1. Give a short history of the potato.
2. What is a potato? Describe the plant and tuber.
3. To what kind of a soil and climate is the potato best adapted?
4. How would you test seed potatoes for disease?
5. How should seed potatoes for planting be cut?
6. State irrigation and cultivation requirements.
7. How is good quality in potatoes secured? How can you tell good quality?
8. Describe a method of seed selection.
9. Give the main points in storage of potatoes.
10. Discuss the problem of variety for a locality. Name some good varieties.

EXERCISES AND PROJECTS

1. Grate several potatoes to fine pulp and shake in water. Allow to stand in a deep, narrow vessel for a few hours. Remove scum and shake. Repeat several times. The white material in the bottom is starch.
2. Cut some potatoes in halves and study structure. Note the three areas. They are cortical, outer medullary, and inner medullary. The dark, irregular part (the inner medullary) is very poor in starch. Make outline drawings and label.
3. Look up in the U. S. Department of Agriculture Yearbooks the five leading potato-producing nations of the world and the ten leading states in the United States.
4. Visit some good potato cellar, storehouse, or a pit that is being filled.
5. Secure a sackful of potatoes. Measure carefully in a good metal measure. In thin board or in heavy pasteboard make a hole 2½ inches in diameter and another 1½ inches. All potatoes that will not pass through the large hole put in one pile. These are Grade No. 1. In a second pile, place those tubers that go through the large hole but not through the small one. Those that pass through the small hole are culls. Keep these separate. The other potatoes are Grade No. 2. Now measure carefully and see if the total volume of the potatoes is equal to first measurement. If there is any difference, explain the reason for it.

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CHAPTER XXIX

ORCHARD FRUITS

Not all farms are adapted to the commercial production of fruit. There are, however, very few farms in the mountain states which could not be made to produce an abundance of fruit to be used by the home. In some localities peaches and cherries might not be successfully grown on account of late spring frosts, but an ample supply of apples, pears and plums, and the small fruits could be raised for home use. In selecting a section of the farm for fruit trees the first important point to consider is the soil.

Soil. Almost any good fertile soil which will grow fair crops of potatoes and vegetables can be made suitable for the apple, pear and plum, which adapt themselves nicely to a soil varying from the sandy loam to the clay loam. The cherry and peach thrive best on a rather light, well-drained soil. It is important, however, that this soil be deep, that is, not too closely underlaid with a gravel or clay hardpan and not susceptible to a high water table, at least within six feet of the surface. If there is not at least six feet of good soil, the fruit tree is bound to be short-lived and unsatisfactory. When a deep soil is selected and other conditions are favorable, the apple or pear tree will flourish and produce fruit during a period equal to the lifetime of an average person. Much importance is attached to the selection of a commercial orchard site free from frost conditions. But the home fruit plantation must necessarily be close to the buildings for convenience in the care of the trees and to get the best use of the crop.

The land should be put in good tillable condition, much the same as for the vegetable garden.

Nursery Stock. In the purchase of nursery stock it is well to patronize a nearby nursery, since the business integrity of the firm and the quality of their trees may be better known. Oftentimes the earlier the order is placed, in the late winter or early spring, the better the stock received. One-year-old trees are preferable in practically all fruits, especially in the case of apples, peaches, and cherries, as trees of this age are less disturbed by transplanting and are more likely to survive this operation. They generally make a more rapid growth from the start than older trees. At the same time the fruit grower is able to prune and shape the head of the trees according to his own ideal much better by beginning with young nursery stock.

Figure 80.—Well grown one-year-old apple trees.

Pruning the Young Tree. A fruit tree should be pruned systematically and periodically each year from the time it is planted until taken from the orchard. At the time of planting cut the bruised and torn roots off to within six or seven inches of the trunk, making a good clean cut. A cut will heal more rapidly than a bruise. The top should be pruned as soon as the tree is planted to maintain balance between the top and the root system. If one-year-old "whips" are planted, they should be cut back thirty inches from the ground at planting. On the other hand, if two-year-old trees are used and the head of the tree has already

Figure 81. — Well-shaped Jonathan tree before its annual pruning. Top branches should be trimmed out slightly.

been formed, from three to five main branches should be selected to make the framework of the tree. These should be distributed as equally as possible around the tree and at the same time arranged up and down a space of eight or ten inches along the trunk. If all the branches are started at the same place on the trunk, the tree will be likely to break down under heavy loads of fruit. The lowest branches should not be less than twenty inches from the ground to facilitate cultivation operations. At the same time, it is well to have a low-headed tree, thus shading the trunk to prevent sun scald and to make pruning, picking, thinning, and spraying more convenient. These main branches of the tree should be headed back to two or three buds at the time of planting; otherwise the tree may start to grow very slowly or even die on account of having too large a top in proportion to the roots. The first year after planting the tree will have six or eight branches from these original five, a part of which should be removed, leaving only about one shoot on each of the five

Figure 82.—A well-shaped three-year-old apple tree before pruning.

original limbs. If a one-year-old whip has been planted, these lateral branches will start from the main trunk. These should be cut back to within eighteen or twenty inches of the trunk to strengthen the young tree, making it more compact and stronger. A year or two of cutting back the main limbs of the tree, when it is first started, may save it from

Figure 83.—Vegetables may be cultivated between rows of fruit trees for six or seven years after trees are planted.

breaking down by heavy crops in later years, but should be discontinued in the case of apples, pears and cherries after the third year.

Pruning the Mature Tree. The mature, bearing tree should receive its moderate annual pruning early in the spring. If it has been properly handled during its early years, the pruning operation will not be laborious or complicated. In removing branches the cut should be made close to the remaining limb without leaving any stub. Long stubs may never completely heal over but smooth cuts will heal readily. The work should be taken up systematically, first removing any lower limbs which interfere with cultivation, then removing from the center all straight watershoot growths which would soon fill the tree. If there are

limbs which make bad crotches, cross one another, or rub together, one of them may be removed. In case the tree is growing too high and out of bounds it may be cut back to a side branch. In cutting back a tree under these conditions one should never simply cut back all the branches,

Figure 84.—Alfalfa or clover may be grown in the bearing orchard if the soil is rich and there is an abundance of water.

but should always make this cut to a lateral growth to which the strength of the tree will go rather than be forced to the upright branches. It is often desirable to do this cutting back in the summertime, as pruning at this time is less likely to stimulate an excessive wood growth. As noted above, pruning should be an annual process, as irregular severe pruning is conducive to excessive wood growth at the expense of fruit production. Detailed methods to be followed in pruning the several different fruit trees cannot be developed within the space of this text, but may be found by those interested in references 1, 2, 8 and 11.

Thinning the Fruit. There is no other factor which is more important in the production of high quality fruit than thinning. It is the common practice of the average farmer

to thin the sugar beets and various vegetable crops that those plants remaining may have more room and better nourishment and attain a more perfect growth. Many of the same farmers will, however, allow an apple tree to be greatly overburdened with the production of a large amount of inferior fruit. The exact amount of fruit to be removed will

Figure 85.—A spring-tooth cultivator is useful in working an orchard, especially a silt loam soil.

have to be learned by experience. If actually one half of the fruit is thinned from the tree, the remaining half will often yield as much bulk as the entire crop would have yielded, besides being greatly superior fruit. The best time to thin the fruit is about the first week in July, immediately after the so-called June drop.

Cultivation. Good cultural conditions are as necessary in the orchard as in the garden. Vegetable crops may be grown between the trees for the first six or eight years after planting the orchard, until the soil becomes too shaded for the intercrops.

The tools to be used in cultivating depend upon the nature of the soil. A spike-tooth harrow might be a very

satisfactory implement for a sandy loam, but an implement designed to cut and break up the clods, such as the Acme harrow, would be more satisfactory on a heavy soil. Irrigation water should be used judiciously and only when the trees need it. No hard and fast rules can be set down for the application of water. The grower will learn to know when the trees are in need of more moisture. Each

Figure 86.—The proper system of irrigation in a western orchard.

irrigation should wet the soil to a depth of six or eight feet, and the trees should never be allowed to suffer for want of water. It is well to remember, however, that injury can be caused by too much water as well as by too little. Trees heavily laden with fruit require much more water than young growing trees, although the latter should be given several irrigations each year to keep them vigorous.

Picking and Storing. Great care should be exercised in picking all fruit crops and especially fruit destined for storage. All fruit should be picked at the proper time in the most careful manner and handled judiciously after being picked. Apples for immediate use should remain on the tree until thoroughly ripe. Apples for winter consumption

should be picked shortly before they have reached the stage of complete ripeness. This point has been reached when the seeds are partially or wholly brown, when the fruit has taken on its characteristic flavor and has become well-colored, at which time the apple will separate from the twig with comparative readiness.

Figure 87.—A three-year-old apple tree. The fruit is borne on the two-year-old wood.

Since most pears ripen best out of the sunlight and are subject to core rot if allowed to remain on the tree too long, it is advisable to pick them early and allow them to ripen in storage. Pears picked green, however, will wilt and become worthless. The proper time to pick a pear is when it has reached its maximum size, become mottled, is yellow at the base, and separates readily from the spur. Several pickings are required to get the best results.

Peaches, for home use, are allowed to remain upon the tree until thoroughly ripe.

Fruit must be handled carefully to keep it free from bruises of any kind. A clean solid apple will keep in storage much longer than a bruised one. With a common cellar for storage, apples may be kept and enjoyed in the average farm family from ten to twelve months, while pears may be held until Christmas. Good ventilation and a temperature of 32 degrees F. is most favorable to apple and pear storage.

Varieties of Fruit. There are many varieties of fruit in existence with a wide range of adaptability. Among those best suited to the semi-arid states are:

EARLY APPLES

Red Astrachan. This is one of the leading summer apples, medium size, greenish yellow, striped and blushed with dark red. The tree is vigorous, early and an abundant bearer. Season, late in July and August. It is very hardy and should withstand the climatic conditions in countries of high altitude.

Yellow Transparent. This variety is next in importance to the Red Astrachan, of medium size, bright yellow, and of good quality for both dessert and culinary purposes. The tree is a vigorous, upright grower, a good early bearer, and withstands severe climates. Season, late in July and early August.

Wealthy. Medium to large, light yellow apple, splashed and mottled with dark red, very attractive. The tree is vigorous, spreading, very productive, and capable of withstanding climatic conditions in the counties of high altitude. Season, September to November in low altitude, and October to January in high altitudes.

Maiden's Blush. Medium-size yellow apple blushed with red, very popular for fall use. The quality is excellent for dessert purposes, cooking, or evaporation. Season, September to October. The tree is vigorous and productive.

WINTER APPLES

McIntosh. Medium-size, bright deep red color, very attractive in appearance, flesh very tender, perfumed and delicious. This is one of the very best dessert varieties for home use and local markets from September to December 1st. The tree is vigorous, very hardy and a reliable cropper.

Jonathan. Medium size bright red apple, of very good quality for dessert and culinary purposes. Season from November to January. This is one of the very best commercial apples.

Winesap. Medium to small, bright red apple, of firm flesh, crisp, and of slightly subacid flavor. The tree is medium in size and vigorous. The size of the fruit is much benefited by thinning. Season, December to April, a good-keeping apple.

R. I. Greening. Large green apple of excellent quality. The tree is vigorous, spreading and a medium to heavy bearer. This variety is most excellent for culinary purposes and regarded by some as good for dessert. Season, December to March.

Arkansas. (Mammoth Black Twig.) A large to medium greenish apple overlaid with dark red, becoming rich garnet on the exposed side. It usually overgrows, and is nonproductive on heavy soils. It

is much more satisfactory on the sandy loams and even here it is sometimes only a medium producer. The flavor is subacid of good quality. Season, December to April.

PEARS

Bartlett. One of the very best pears for home use but very susceptible to blight. A large clear yellow pear with reddish blush and of fine quality. Season, about the 20th of August in Box Elder County, Utah.

Flemish. Often known as Flemish Beauty: A large yellow pear nearly covered with a russet red blush. The flesh is a little coarse, but juicy, sweet, rich and highly flavored. Season, September.

Lawrence. Medium size, fruit light yellow with many small dots and of good quality. Season, about September 15th, but will keep in common storage until December.

Winter Nelis. Yellowish green pear, much russeted, fine grain, sweet and of good quality. It can be picked just before frost and will keep until December.

Anjou. A large, short-stemmed, greenish yellow pear, sprinkled with russet and a dull red blush. It has fine juicy flesh and is of good quality. Season, about September 15th, but may keep in common storage until December 1st. It is likely to be a scant bearer.

PEACHES

Alexander. A medium to small yellowish white peach, covered with deep red blush on the sunny side. Its flesh is white, firm, juicy, and of good quality, with stone nearly free. It is one of the best early varieties for local trade and home use.

Early Crawford. A large bright yellow peach with a red cheek. Often the yellow surface is sprinkled with red splashes. Its flesh is yellow, juicy, sweet and of very good quality, with a free stone. It is widely grown in some sections as a commercial peach. Season, early to medium.

Triumph. A large yellow peach, overlaid with red. The flesh is deep yellow, juicy, and of good quality. Semicling. Medium season. It is one of the best early yellow flesh varieties.

Early Elberta. A large yellow peach with a crimson blush. The flesh is yellow, of good quality and has a free stone. The tree is vigorous and very productive. Season, late summer, a week or ten days earlier than Elberta; but it has a very good keeping quality.

Elberta. The most widely known commercial peach. It has large round yellow fruit with a dark red blush on the sunny side. The flesh is pale yellow, tender, juicy, and of medium quality. It is a good shipping peach. Season, medium to late. The trees are strong, vigorous, and heavy bearers. This variety is inclined to thin itself.

Orange Cling. A large orange yellow peach with red cheek, firm juicy flesh, of good quality, and with a cling stone. Season, about ten days later than the Elberta.

SWEET CHERRIES

Napoleon. (Royal Ann.) Large, heart-shaped, yellow cherry with bright red blush, and with a very firm, sweet juicy flesh. It is one of the very best varieties. Season, last of June to first of July.

Black Tartarian. Medium to large black cherry, with dark flesh, and of fine, mild, sweet flavor. Season, middle of June.

Bing. One of the newer dark red, nearly black, sweet cherries, very large and of excellent flavor. It promises to be one of the leading market varieties. Season, a little later than the Black Tartarian.

Lambert. It is very similar tc, and seems to be as meritorious as, the Bing.

Winsor. A very dark red cherry of firm flesh and good quality. Season, about the same as the Napoleon.

SOUR CHERRIES

Montmorency. One of the leading sour cherries, medium in size, light red, but less hardy than many of the smaller kinds. It makes a good appearance when canned.

Knudson. A very hardy, mild sour cherry, bright scarlet in color and having medium to large fruit. It is one of the most attractive pie and canning cherries in existence. It is a very early bearer, and ripens its fruit over a long period.

PLUMS

Abundance. A yellowish fruit nearly overlaid with bright red, of yellow flesh and good quality. Season, early. This Japanese variety blooms early and is, therefore, liable to frost injury in unprotected sections.

Bradshaw. A dark purplish red plum, with medium to large fruit. Its flesh is greenish yellow, sweet, and of good quality. The stone is nearly free. Season, middle of August.

Italian Prune. One of the most widely grown and most popular varieties of medium size, dark purple, with a greenish yellow flesh, juicy, sweet, and of good quality. It has a free stone. Season, late August to September. It is extensively grown for dried prunes, as well as for market purposes.

Giant (Giant Prune). A very large dark crimson fruit, with yellowish flesh of good quality. It is considerably grown for market purposes.

Damson. A small purplish plum, with a melting, juicy flesh of subacid flavor. It has a free stone. Season, medium. It is an exceptionally heavy producer and is largely used for preserving.

Golden Drop (Silver Prune). One of the largest and best quality yellow plums, especially adapted to the home fruit garden in the semi-arid states. Season, late.

De Soto. A medium-size oval plum, orange yellow, mostly overlaid with crimson, and of very good quality. Season, medium. It is a hardier variety than any of the above and valued for preserving.

QUESTIONS

1. Discuss favorable and unfavorable soil conditions for fruit trees.
2. At what age should nursery trees be purchased? Why?
3. Discuss the pruning of the young tree to shape the framework branches.
4. Discuss the pruning of a mature fruit tree.
5. Why is fruit thinned, and how?
6. Discuss the cultivation and irrigation of fruit trees.
7. How can one judge the proper season to pick apples, pears and peaches?
8. Name and describe briefly three varieties of each of the following: apples, pears, cherries, plums.

EXERCISES AND PROJECTS

1. *Grafting:* Apples are sometimes propagated by means of grafting a twig, called the cion, to a root of a tree, called the stock, which is one year old. This is because a twig will always produce the same kind of apples as the tree from which the twig is cut; whereas an apple seed usually produces a tree which bears some other kind of apples.

   For practice in grafting it is wise to use only the twigs bearing good, plump buds. Cut two pieces of twigs about six inches long. Cut off the end of each piece with a long slanting cut,

Figure 88—Illustration of whip-grafting showing: A, the method of making the cut; B, the stock and cion spliced together; and C, the splice wrapped with waxed string.

the surface of the cut being about an inch long. Practice until the cut can be made with one stroke of the knife, thus securing a smooth surface. Now, starting near the tip of slant, split the twig down as far as the other end of the slanting cut. Repeat with another twig of about the same size and fit the two cut ends into each other. Fit them in such a way that the line between the wood and the bark on each piece touches the same line on the other piece. Wind the splice tightly with string and the graft is finished. If the lower piece were a root, the two pieces would unite and could be planted to grow into a tree.

2. *Budding:* Apples are also often propagated by budding. A piece of bark bearing a bud is inserted under the bark about four inches above the ground on a two-year-old tree grown from a seed. The bud grows and the top of the old tree is cut off, the growth from the bud becoming the new top.

If the work is done in the late spring, the buds may be inserted, for practice, in branches about an inch in thickness. If done in the fall, the budding may be practiced on willow branches an inch thick which have been boiled or steamed to make the bark slip.

Select apple shoots bearing dormant buds. Starting an eighth of an inch above the bud and cutting the same distance below, cut off a piece of bark with the bud in the middle. On the apple branch or willow stick, which is called the stock, make an inch-long cut lengthwise of the branch. At one end of this cut make a short cross cut; both

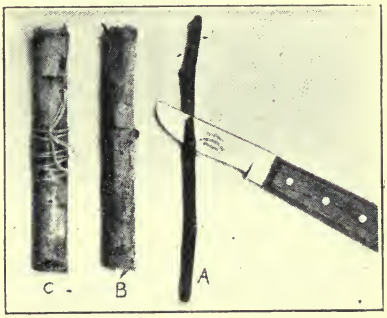

Figure 89.—A, cutting the bud; B, bud partly inserted under bark; C, bud inserted and tied.

cuts need go only through the bark. Lift the corners of the bark with the point of the knife and then thrust the bud under the bark in such a way that the bud faces out through the vertical cut. Wind the branch tightly with string to press the bud against the branch.

If the work is rightly done on a growing tree in the spring, the bud will unite with the stock in about two weeks. The string may then be cut off and the bud will soon begin to grow.

3. *Fruit Bud Studies:* Fruit trees bear two kinds of buds: (1) leaf buds, or those which open out and make leaves and later develop into branches; and (2) fruit buds which develop into flowers and later into fruit. There is a difference in appearance between leaf buds and fruit buds, especially in the apple. The fruit bud is large and plump, whereas the leaf bud is smaller, narrower, and more pointed.

Figure 90.—Twigs of: A, cherry; B, plum; C, apple; D, peach. showing: F, fruit buds, and L, leaf-buds. Numerals 1, 2, and 3 show age of wood in years; O indicates divison between the different ages of wood.

In the spring of the year, bring in branches of different kinds of fruit trees and set them in water. Draw parts of the branches to show different kinds of buds and label them. In general, the different fruits bear buds as follows:

(a) Apples—fruit buds are terminal on short twigs called spurs. The fruit buds are sometimes terminal on wood which was formed last summer. Pear fruit buds are like those of apples.

(b) Plums—fruit buds are lateral on spurs and the terminal bud is a leaf bud. The buds are long and more pointed than apple buds.

(c) Cherries—fruit buds are lateral on short spurs and are usually in a cluster near the tip of the spur. Fruit buds may also be lateral on long shoots grown last summer.

(d) Peaches—bear their buds in groups of three. The fruit bud is the small central bud on wood grown last summer. The two outside buds are leaf buds.

Leave the branches in water for a few weeks until the buds have opened and the flowers bloomed, then see if you have labeled the buds in your drawings correctly.

When fruit trees are in bloom in the spring study the buds out of doors, noting just where the buds which produced flowers and those which produced only leaves and branches were situated on last year's wood. Were the buds lateral or terminal? Were they on short spurs or on long shoots of wood?

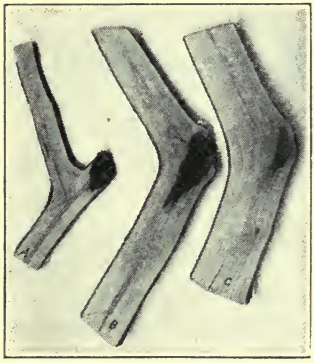

Figure 91. — Longitudinal section of branches showing: A, branch cut off leaving a long stub which will not heal over; B, properly made cut healing over from above; C, properly made cut healed over.

4. *Cutting off a Branch:* One of the first principles to be learned in pruning fruit is the proper method of cutting off a branch. When a branch is removed, there is left a tender cut surface open to attack of various diseases which may enter the tree at that point and eventually kill it. To prevent this result, the cut should be made in such a way that the wound will heal rapidly. This exercise demonstrates the proper method of making the cut.

The tools necessary are either a pair of pruning shears or a saw and a sharp knife. The work may be done on any kind of a tree. In winter, choose a branched limb about one half or three fourths of an inch thick. Cut off the branch about one inch away from the limb, leaving a stub (as shown in A, Figure 91). If the cut is made with the saw, the surface will be rough and should be smoothed with the knife. Now choose another branched limb of the same diameter and cut off the branch close up to the limb, leaving a smooth surface and no projecting stub (as shown in B, Figure 91). Watch developments in the healing of the two cuts. Explain. From which

side of the wound does healing take place most rapidly? (C, Figure 91, shows a close cut wound which has healed completely.)

5. In case somebody is available who is familiar with pruning, the class may be taken to an orchard and taught how to prune various kinds of trees. This exercise, however, requires considerable knowledge of pruning.

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CHAPTER XXX

SMALL FRUITS

BUSH FRUIT CULTURE

The bush fruits, composed of raspberries, blackberries, currants, gooseberries, and dewberries, require essentially the same attention.

Soil. Well-drained, sandy loams give the best results. The dewberry, however, thrives best on a gravelly loam. If the soil is too rich, the plant produces vine at the expense of fruit. Sod land should be avoided. Thorough soil preparation is imperative. Land which has been thoroughly cultivated for one or two seasons previous to planting is to be preferred.

Fertilizers. Bush fruits do not require heavy fertilizing. Land which fails to give satisfactory returns in some of the vegetable crops will often give good yields of bush fruits without the addition of fertilizers of any kind. Fertilizing should not be neglected entirely. A moderate application of stable manure gives good results especially with currants, gooseberries, and raspberries. Upon fertile soils it must be used cautiously, as otherwise it may cause excessive wood growth, lack of hardiness, and diminished fruitfulness. Apply in fall or early winter, that it may become available during the early part of the growing season.

Care of Young Plants. It will seldom be convenient to set out the plants immediately upon their arrival from the nursery. They should, however, be unpacked as soon as received. The bunches should be loosened up enough to bring all the roots in contact with the earth when heeled in. The north side of a building or a cool cellar should be used as

a place in which to heel them. Open a shallow trench with one side somewhat slanting, lay the plants against this side, and cover the roots with fine damp soil, packing it firmly about them. If heeled in a cellar, damp sawdust may be used to cover the roots.

Figure 92.— Houghton, one of the standard gooseberries.

Setting the Plants. The plants should be set out very early in the spring; otherwise the first season's growth will be seriously checked. Spring planting is preferable to fall planting in the semi-arid West. The common practice is to plant bush fruits in rows furrowed out six to eight feet apart, with the plants two to six feet apart in the rows, depending upon whether the planting is done in solid rows or in hills. The plants are easily set in mellow ground by working the soil about the roots, firming it with the feet. The furrow between the plants may be filled in by subsequent cultivation. The plants should be carried in a pail of water or wrapped in wet burlap. Never distribute the plants more than a few feet ahead of the planter. A very few moments of exposure in the sun or wind will lessen the vitality of the plants or even kill them. Unless the weather is cool and rainy, the plants should be irrigated as soon as set. This first irrigation is quite essential even though the soil is already damp, for water firms the loose soil around the roots.

Soil Management. Cultivation during the first season will be the same as for any hoed crop. Frequent stirring of the soil to destroy weeds, and frequent irrigation, followed by cultivation, are recommended as good practice throughout the first season. Each succeeding spring tillage should begin early, using any implement which will thoroughly loosen the soil and leave it level. The soil near the plants should be loosened with a hoe or rake, so that the entire surface may be mellow and in good tilth. This cultivation should be done early in the spring before the ground becomes hard and weeds are established.

Figure 93.—White Imperial currant.

Pruning. The brambles (raspberries, blackberries, dewberries, etc.) bear their fruit on one-year-old canes. As soon as the fruiting season is past these canes should be cut out and burned, thus making room for the new growth and destroying insects and diseases. In common practice, however, the pruning is neglected until the following spring, when the old dead canes are taken out and the tips of the young canes cut back to varying extents, depending on the variety.

Currants and gooseberries bear their best and most fruit on the branches which are from one to three years old. New branches are produced each year and these should replace the old branches which bear only inferior fruit in small quantities. Hence, in pruning, which should be done in the early spring, all branches are cut out except a few each of the one, two, and three-year-old branches. In exceptional cases good results

may also be obtained by leaving some branches which are four and five years old. The tips of the branches may be cut back in some cases for various reasons, but this is usually not necessary.

Propagation. The methods of propagation are by division of the parent plant, suckers, mounding or cuttings, and tip layering, according to the habits of the species.

Picking the Fruit. Never pick the fruit when it is wet, unless it is positively necessary in showery weather. When picked in this condition the fruit is suitable only for preserving or immediate consumption. Damp fruit quickly becomes moldy in transit or storage.

STRAWBERRY CULTURE

Soil. A well-drained, rich sandy or gravelly loam will give good results in the production of strawberries. Although this crop requires considerable water during the ripening season of the fruit, it will not pay well on a poorly drained soil. In general, strawberries require soil conditions desirable for a vegetable garden.

Liberal applications of stable manure should be part of the yearly treatment of the strawberry patch. It can be applied in the late fall or winter, thus serving as mulch as well as fertilizer. If there is a light snowfall, this mulch will often reduce the likelihood of the winter killing where the climate is severe, and it may also prevent the plants from blossoming until after late spring frosts.

Propagation and Culture. In starting a new bed the plants should be set out as early as possible in the spring, in order that they may be well established before hot weather.

Strawberries do not come true from seed; therefore varieties are propagated vegetatively by means of runners. In setting out a new patch only young plants which have never borne fruit should be used. Three years is about the average life of a commercial strawberry patch, some growers harvesting only two crops. The land is then used for some hoed crop for

two years before replanting to strawberries. Before planting, the roots should be pruned back to about five inches. They will then branch, producing a thick, matted root system.

If the plants are set deeper than they were in the old bed, the crowns become covered with soil, thus killing the plant. If set less deeply, the roots dry out just below the crown, causing dwarfed growth or the death of many plants.

The plants do best when set from fifteen to twenty-four inches apart in rows from three to four feet distant, depending somewhat on the varieties used.

Pollination and Varieties. In choosing varieties, attention must be given to pollination. Some varieties produce only imperfect flowers, that is, flowers in which pistils are present but no stamens. These are known as pistillate varieties. This type will not produce fruit when planted alone, but must be grown in the vicinity of pollen-producing varieties known as staminate varieties. When a pistillate variety is planted it should be alternated about every third or fourth row with one or two rows of a staminate variety which blossoms at the same time. All the following varieties have perfect flowers and are among the most popular sorts grown in the western states: Jucunda (early); Dunlap (early to midseason); Marshall (midseason); Chesapeake (midseason to late); Klondike (late).

Tillage. Frequent shallow cultivation the first season is essential to the establishment of a first-class strawberry bed, in fact, the area should be treated in a manner similar to a hoed garden crop. All blossoms should be picked off the young plants the first year that they may not become dwarfed by premature fruit bearing.

Irrigation. The plants should make a continuous healthy growth and never suffer for want of moisture. The bearing strawberry bed needs frequent and liberal irrigation during the fruiting period. Lack of ample moisture will result in undersized, inferior berries.

Picking. The berries should be picked carefully without bruising. Fruit for market should be picked every day, since it will remain firm and transportable only a short time. For near-by markets the berries may be fully ripe when picked, but must be firm. For distant markets the fruit should be picked when about three quarters to seven eighths red. Fruit in this condition is full size, and will ripen and color in transit, reaching the market firm and presentable.

Berries should not be picked when wet. Wet berries decay quickly and will not stand transportation. Remove the berries to a shady place or packinghouse as soon as possible after picking.

Marketing. Strawberries are usually marketed in quart cups or baskets. Some states have laws prohibiting the sale of strawberries in any other containers. These quart baskets are usually shipped in crates holding from twelve to thirty-six baskets, depending on the market demands.

If the fruit be graded, each crate presents a uniform appearance throughout as regards color, size, and ripeness of the fruit. To accomplish this result only one variety should be packed in a crate. When a dark red variety and a light red one of equal merit are packed together, the light berries usually appear to a disadvantage, whereas they would make a very creditable showing by themselves. Some of the fancy markets prefer to have the top layer of berries in each cup "faced." They should be packed honestly and the fruit on top should be a fair sample of the contents of the basket.

GRAPE CULTURE

Even though grape culture is not an extensive commercial enterprise in the western plain and intermountain states, nevertheless grapes could be produced for home use on many of the farms throughout this territory.

A very severe winter climate will kill grapes and very late spring frosts will reduce the crop; whereas in a short growing

season the crop may be destroyed by early fall frosts. Grapes, however, can be produced in almost any climate which is favorable to the growth of cherries or peaches. There are many varieties of both the European and American grape, which make a group with a wide range of adaptation.

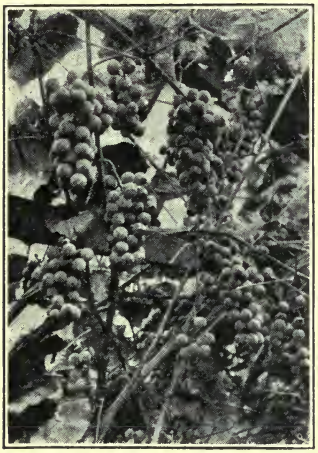

Figure 94.—Concord grapes.

Varieties. The following varieties are among the most popular hardy American grapes: Campbell Early (early); Concord (midseason); Niagara (midseason); Catawba (late).

The European grapes should be planted only in the semi-arid West, and where there is a long growing season, as in the valleys contingent to the Great Salt Lake; Grand Valley, Colorado; Boise Valley, Idaho; at a maximum altitude of about 4,500 feet; together with the lower valleys of southern Utah, southern Colorado, Arizona, New Mexico, Texas, and California.

The European varieties which are adapted to the above region are: Black Prince (early); Sultanina (early); Alexandria (midseason); Ferrara (midseason); Cornichon (late). The American varieties are also suited to home use in this latter region.

For a detailed description of grape culture and pruning, see references 5, 6 and 7 at the end of this chapter.

QUESTIONS

1. What is meant by bush fruits?
2. How does the dewberry differ in soil requirements from the other bush fruits?
3. How should bush fruits be fertilized?
4. What is meant by "heeling in" plants and how is it done?

5. Discuss the season and method of setting out bush fruits.
6. When and how are blackberries and raspberries pruned?
7. Discuss the pollination of strawberries, and name four perfect flowered varieties.
8. Discuss the picking of small fruits, and their subsequent handling.
9. What are the three principal climatic limitations to grape culture in the mountain and western plain states?

EXERCISES AND PROJECTS

1. *Pruning Brambles:* In order to produce good strong fruiting wood and still not have raspberry bushes too tall or too long, it is necessary to prune the new canes before they fruit.

   Blackberries and black raspberries are pruned in spring of the first year. When the young canes are 1½ to 2 feet high the tips are pinched or cut off and the cane sends out strong stocky branches which bear good fruit. In the spring of the second year these branches are cut part way back in order to prevent too much fruit.

   Red raspberries are not pinched the first year, but are allowed to grow the first year. In the spring of the second year, these one-year-old canes are cut back to three feet in length.

   In the winter go into a bramble patch which has not been pruned and notice the two different kinds of canes. What external differences do you see? Cut some canes in two and note internal differences. Which should be removed entirely? Why? Remove all the dead canes, and enough of the new canes to leave only three to five in each hill. If the new canes are branched, trim back the branches.

   In the spring, pinch back the new canes of blackberries or black raspberries when they are from 1½ to 2 feet high and watch the results. Let some grow to four feet tall and then cut them back to 1½ to 2 feet long. Compare the results of the two treatments through the rest of the life of those particular canes.
2. *Pruning Currants and Gooseberries:* Although the pruning of these fruits is probably neglected more than that of any other, they nevertheless respond readily to pruning.

   The best fruit is borne on one-year-old canes and on the one-year-old spurs of canes two and three years old. After a cane becomes four years old, its fruit becomes scarce and small; therefore, all canes four years old or older should be removed.

   In the winter go into a currant or gooseberry patch which has not yet been pruned. Count the age of the various canes and you

will find some canes one, two, three, and four years old or older. Cut off at the ground all those which are four years old and older, and cut off all but five or six of the one-year-old canes. How do the one-year-old canes differ from older canes?

This treatment will thin out all dead, weak, and superfluous wood, thereby yielding a better crop.

3. *Planting Strawberries:* Secure from a reliable company or grower 25 or 50 strawberry plants to be delivered in the early spring. Be sure to select a variety which is bi-sexual, that is, one which produces both pollen and pistils. Why? As soon as the plants arrive, dig a shallow trench, open the package of plants, and spread the plants out in the trench covering the roots firmly with soil. Do not cover the crowns of plants. Keep the plants well watered.

When the ground has been prepared, set the plants in rows three feet apart setting the plants fifteen inches apart in the row. Dig a shallow hole and set a plant into it, taking care to spread the roots out evenly; then cover with dirt and press down firmly all around the plant. The plant should be set at such a depth that the crown is just at the surface of the ground and neither above nor below it. If the soil is dry, each plant must be well watered.

Strawberry plants should not be allowed to set fruit the first summer. It is necessary to entirely remove all blossom stalks as fast as blossoms appear during the first summer.

If the hill system is used, it is necessary to cut off all the runners from the plants as fast as they appear.

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CHAPTER XXXI

THE VEGETABLE GARDEN*

The vegetable garden should be a valuable asset of every farm home and can well be worked in at the rear of many town lots. All tillage should be done, where space will allow, with horse tools. The rows of vegetables, therefore, should be long and continuous. If it is not desirable, however, to grow one full row of any vegetable, the row may be made up of several crops, which demand similar cultural methods, as turnips, radishes, and beets, which would all thrive under the same conditions. It is essential that the soil be rich and very thoroughly pulverized, and very careful, frequent, and painstaking cultivation is necessary. In the semi-arid regions this must be supplemented by irrigation every week or ten days to produce a rapid succulent growth which is so essential to high quality in most vegetable crops.

The perennial plants, such as rhubarb, asparagus, and herbs should be arranged on one side of the vegetable garden in order not to interfere with the annual plowing. The above hardy vegetables should be in rows three to four feet apart to permit horse cultivation, with the plants about two feet apart in the rows. It is well to practice some system of rotation with the annual vegetables, growing them in different parts of the area in succeeding years. If radish or cabbage maggots or other insect pests become thoroughly established, omit for a year or more the vegetables on which they live.

It is not necessary that the crops should be confined to vegetables. Oftentimes a sprinkling of flowers here and there brightens up the area and makes it more attractive than when planted entirely to the culinary crops.

*The culture of potatoes is omitted from this chapter, as this crop is treated in detail, pp. 208.

Size. The home vegetable garden for a family of five or six persons would require, exclusive of potatoes, a space of about 100 by 150 feet. If several plantings of the respective vegetables are made throughout the season, a family can be provided with a wide variety of vegetables from early spring to late autumn.

Hardy Vegetables. Vegetables that are hardy, withstanding a light frost, may be planted in the very early spring, as soon as the apricot trees are in blossom. Beginning at one side of the garden the rows may be made the short way, having each row 100 feet long and two and one half to three feet apart to allow for horse cultivation. Sowings of the following may be made as the ground is in condition to work: 50 feet each of parsnips and salsify; 100 feet of onions; 50 feet of early beets; 50 feet of lettuce, with which radish seed may be sown to break the soil and to be harvested before the lettuce needs the room; 100 feet of early cauliflower; 100 feet of early cabbage plants which should have been started in a cold frame or may be purchased from a greenhouse; 400 feet of peas,—early, medium and late varieties.

Tender Vegetables. After the soil has become thoroughly warm and the normal danger of frost is past, the tender vegetables may be planted. After the apple trees have blossomed and dropped their petals this group of vegetables may usually be planted with safety. The following planting should supply the above family: 100 feet each of early, medium and late string beans. Sweet corn may be planted in about 5 rows, 3 feet apart, and about 2½ feet between the hills in the row, —early, medium, and late varieties. Twelve hills of Hubbard squash in rows 6 feet apart, with the hills alternating 8 feet apart in the row; 6 hills of early squash (such as the Boston Marrow), 6 by 6 feet; 12 hills of cucumbers, 6 by 6 feet; 20 hills of muskmelons, two or three different varieties, 6 by 6 feet; 20 egg plants, 2 feet apart in the row; and 100 feet of tomato plants. Late cabbage, cauliflower, celery, and

Brussels sprouts may occupy the space made vacant by the removal of the early crops, such as lettuce, radishes, early peas, and string beans. On the border of a garden, an asparagus bed 25 feet long and 6 feet wide will furnish enough for family use. Bordering this, about a dozen clumps of rhubarb set 3 feet apart each way should be regarded as part of the permanent garden. Cold frames and hotbeds may be set along the border next to these perennial plants. Next to the hotbed sage, mint, hyssop, and parsley may be planted.

Classes of Vegetables. It will greatly aid the beginner in vegetable culture if he recognizes certain groups or classes and is familiar with their requirements for successful growth.

Root Crops. Beets, carrots, parsnips, radishes, salsify, turnips, rutabagas, require a cool season in a deep rich soil. They are grown in drills and are usually not transplanted. They may be used, though, as a main-season or as a secondary crop. They are hardy and require no special skill in growing them. Loose, deep soil, free from clods, is required to grow straight, well-developed roots. Land should be perfectly drained, not only to remove superfluous moisture, but to provide deep, friable soil. A sandy loam is generally desirable, provided the soil is not likely to become too hot in the summer time. These crops, with the exception of the radish, can be kept in an ordinary cellar throughout the winter and well into the spring by packing them in barrels or boxes in damp sand, allowing each root to come wholly or partially in contact with the sand.

Bulb Crops. The bulb crops including onion, leek, garlic, and chive, are very hardy. They are cool weather plants, demanding unusually careful preparation of the surface soil at time of seeding. A rich friable soil with an abundance of quickly available plant food is essential. These crops may be planted in the spring as early as the ground is workable. The seeds are sown directly where the plants are to stand, in rows from 11 to 13 inches apart for hand cultivation, and

2½ to 3 feet apart for horse cultivation. For early onions, however, there has arisen within the last few years, the special practice of transplanting the seedlings from hotbeds.

The Cole Crops. Cabbage, kale, Brussels sprouts, cauliflower, and kohl-rabi, are hardy and demand a cool season, a deep, cool soil, and an abundance of moisture at the root and should, therefore, receive frequent thorough irrigation. They will not endure standing water, however, closer to the surface than three feet. With the exception of kale and kohl-rabi, this group is generally started in seed beds and then transplanted to the garden when they have from four to six leaves on a plant. In the northern states the plants for these early crops are started in the hotbed or greenhouse from the last of February to the last of March. They may be transplanted in the open ground April 15th to June 1st, depending on the season and location, in fact any time after the land can be prepared. Often late cabbage and cauliflower seeds may be sown in the hills in the open ground where the plants are to mature. In either case the plants are grown about 24 inches apart in rows 3 feet apart.

The Salad Crops. Lettuce, endive, chicory, cress, parsley, celery, and celeriac, in general require a cool moist soil which retains a large amount of moisture but which is, nevertheless, well-drained. A quick, continuous growth is necessary if the best results are to be obtained. These crops are often benefited by a special application of quickly available fertilizer, such as well-rotted manure, harrowed in just before the plants are set. Lettuce, celery, and celeriac are usually handled as hotbed or seed bed crops and transplanted to the garden, while the remainder of this group are usually planted where they are to grow. For the small home garden it is frequently more satisfactory to purchase these plants from commercial gardeners, than to try to produce them at home. Lettuce, endive, chicory, cress, and parsley may be planted in rows about 18 inches apart with

the plants 10 to 12 inches apart in the row. Celery, however, should be given 3 to 5 feet between the rows, depending upon the methods used in blanching. The plants may stand 6 inches apart in the row.

The Potherb Crops include the plants used as greens. Both salad crops and greens should be eaten more universally by the American people than they are. They aid digestion and

Figure 95.—Raising lettuce for commercial purposes.

tone up the system, and because of the minerals they contain, especially iron, they are among the most healthful of vegetables. We should, therefore, use them much more frequently than we do.

Greens may be divided into two groups: first, the spring greens that require a cool season for their best development; second, those that can endure the warm season. The common spring greens are spinach and mustard; the summer greens are Swiss chard, New Zealand spinach, kale, collards, and dandelion.

Since the potherb crops are grown for their leaves, they should make a quick continuous growth in order that these may be crisp and tender. This means that the soil must be in excellent condition, well-watered, and with an abundance

of available plant food, especially nitrogen. All these crops may be sown in early spring. The cool-season greens will be ready for use before the hot weather and the warm-season crops will produce greens all summer. They are all sown in rows from one to three feet apart except New Zealand spin-

Figure 96.—Raising celery for commercial purposes.

ach, which is planted in rows three to four feet apart because of its spreading habit. The summer greens should be so thinned as to stand from six inches to one foot apart in row.

Solanaceous Crops. Tomatoes, egg plants, peppers, and husked tomatoes (ground cherries) are susceptible to frost injury and thrive best on the light, sandy or gravelly soils with a warm exposure. As this group is killed by the first frost in the fall, the size of the crop depends largely upon an early start of the plants in the spring. They should, therefore, be started in hotbeds, frames, greenhouses, in boxes in the kitchen window or vigorous plants should be obtained from a local gardener. It is highly important that the young plants be kept continuously growing. Therefore they need an abundance of quickly available fertilizer. This can best

be supplied by well rotted stable manure. This group is generally grown in rows about 3 or 4 feet apart and 2 or 3 feet between the plants in the row. These crops often follow early cabbage, lettuce, or radishes.

Cucurbitaceous Crops. These crops include the watermelon, muskmelon, squash, pumpkin, and cucumber. These annual plants are susceptible to frosts and require a very warm season and a full exposure to the sun, thriving best on a light, well-drained, sandy loam soil. They are long seasoned crops and it is essential that they receive an early start in the spring and keep growing continually to mature the crop before the early fall frosts. They are grown in hills and are usually planted in the field where they are to mature. This entire group is transplanted with such great difficulty that it can be accomplished only by planting the seed in pots or boxes and not disturbing the roots in transplanting. This method is sometimes followed by market gardeners in obtaining a very early growth. Pumpkins and squashes may be planted 6 to 8 feet apart each way; cucumbers, muskmelons, and watermelons, 6 by 6 feet.

Leguminous Crops. Leguminous crops in the garden are chiefly peas and beans. While the bean is very tender to frost injury, the pea plant is exactly the opposite, withstanding very severe frost. Except this difference, the requirements for successful culture are very similar. Only a medium rich soil is required, as an excessive amount of plant food tends to the production of vine at the expense of pods. Light, sandy to gravelly loam is desirable. Plants are grown in rows about 3 feet apart with plants standing 6 or 8 to the foot in the row. The very tall peas are grown on some form of trellis, as chicken wire or brush.

Sweet Corn. Sweet corn is grown for the immature ears which are eaten when the grains are yet soft. While this is practically unknown in other sections of the world, it is one of the important vegetable crops in North America. Cul-

tivation of sweet corn is similar to that of field corn and requires no great attention or skill. If possible, early and warm soil should be selected, as the first sweet corn for the table is always especially appreciated. It is generally planted about 3 feet apart in the rows and the plants 2½ feet to 3 feet in the row. On account of the wide range of maturity a rather continuous succession can be obtained by planting early, medium, and late kinds at the same time.

Perennial Crops. These consist of asparagus, rhubarb, sage, catnip, horse-radish, and mint. The culture of these crops differs from that of the other vegetable crops in that they are more or less permanent fixtures in the garden and should be given space at one side of the area where the customary annual plowing and tilling will not interfere with their growth.

TABLE IX.*—Amounts of Seed for 100 Feet and Standard Percentages of Germination

Vegetable	Amt. of Seed for 100 Feet	Per Cent	Vegetable	Amt. of Seed for 100 Feet	Per Cent
Asparagus....	66 roots	80-85	Onion seed..	1 oz.	80-85
Beans, String	1 pint	90-95	Onion sets...	1 qt.	80-85
Beans, Lima	1 pint	90-95	Parsley.....	1 pkt.	70-75
Beets.....	2 oz.	150	Parsnip.....	1 oz.	70-75
Cabbage....	1 pkt.	90-95	Peas.....	1 to 2 pints	93-98
Carrot.....	1 oz.	80-85	Pepper.....	1 pkt.	80-85
Cauliflower..	1 pkt.	80-85	Potato	6 to 7 lbs.	.....
Celery.....	¼ oz.	60-65	Pumpkin....	1 oz.	85-90
Chard, Swiss	2 oz.	.....	Radish.....	1 oz.	90-95
Corn, Sweet.	1 pint	85-90	Salsify.....	1 oz.	75-80
Cucumber...	1 oz.	85-90	Spinach.....	1 oz.	80-85
Eggplant....	½ oz.	75-80	Squash.....	1 oz.	85-90
Kohl-rabi...	1 pkt.	.....	Sweet Potato	3 to 4 lbs.	
Lettuce.....	½ oz.	85-90		or 75 plants	.....
Mustard....	½ oz.	90-95	Tomato.....	2 pkts.	85-90
Muskmelon.	1 oz.	85-90	Turnip.....	½ oz.	90-95
Okra.....	1 oz.	80-85	Watermelon.	1 oz.	85-90

*Adopted from Univ. Ill. Cir. 198, p. 22, 1917.

Commercial Gardening. This discussion of vegetable gardening has been taken up largely from the viewpoint of the home vegetable garden. Vegetable gardening as a business is a profitable, healthful vocation for such persons as are especially adapted to intensive agriculture. It requires very close attention to details and only the most energetic workers will be successful in this business. Such workers, with a good market, will be amply repaid for their skill and labor.

QUESTIONS

1. Discuss the preparation and management of soil for the production of good quality vegetables.
2. Submit a plan for a home vegetable garden, for the average family.
3. Give the general cultural requirements for the following different groups of vegetable crops:
   Root crops, cole crops, salad crops, solanaceous crops, cucurbitaceous crops.

EXERCISES AND PROJECTS

1. *Building a Hotbed:* Before the ground freezes in the fall, dig a pit six feet square and thirty inches deep. This pit should be dug on the south side of a building, or in any place protected from cold winds and yet open to the sun all day. Fill the pit with leaves or straw to keep the snow and frost out.

   Secure some two-inch planks and build a frame six feet square. Build it with the board on one side six inches wider than the board on the opposite side. The frame will then slope toward the sun and get more light. The end boards should be cut diagonally to fit to side boards. Set the frame on stakes over the pit in such a way that the bottom of the frame will be even with the top of the ground. Be sure that the lower side of the frame is toward the south.

   About March 15, have the pit filled solidly by means of trampling, to within six inches of the top with *heated* manure. (Any farmer can furnish heated manure on two weeks' notice.) Cover the manure with six inches of good soil. Now cover the frame with two hotbed sashes which are made three feet wide and six feet long. (Any carpenter can make them.) Get a good Fahrenheit thermometer and thrust it through

the soil into the manure. The temperature may rise as high as 120° F. within the next few days. When the temperature goes down to 90° F., the bed is ready for seed sowing.

2. *Growing Plants in a Hotbed:* When the hotbed described in Exercise 1 is ready for seed sowing, divide it into two parts. First see that the soil is well broken up and smoothed. With a pointed stick, make shallow trenches about eight inches apart across the bed from north to south. In one side of the bed plant a few rows each of "French Breakfast" and "Scarlet Globe" varieties of radishes and "Grand Rapids" leaf lettuce. Sow thickly and cover with about ¼ inch of soil, tamping lightly over the rows. In the other side of the bed, plant in a similar way seeds of "Stone" tomatoes and "Early Jersey Wakefield" cabbage. When an inch high, thin out the radishes to one inch apart, and the tomatoes and cabbages to three or four inches apart. The soil should be well-watered but only on bright, sunny mornings. While the weather is cold, keep the glass covered at night with straw or burlap but remove the covering when the sun is shining. During March and part of April the sash should be lifted at the end away from the wind during the hottest part of day and closed before it becomes chilly in the afternoon. As the days get warmer and longer, the sash may be lifted farther and kept up longer during the day until finally they are left off altogether during both day and night. The radishes and lettuce will be ready to eat in from three to four weeks from the time of planting.

3. *Transplanting Tomatoes and Cabbages from the Hotbed:* In the spring, as soon as the ground is dry enough, prepare a small piece of ground in the garden, by spading twice and then raking smooth. Mark off the garden each way in rows three feet apart. When all danger of frost is over, it is time to transplant the plants from the hotbed. Dig up each plant separately with a large ball of dirt on the roots. Take the plants immediately to the garden and plant them at once in order to prevent wilting. At the intersection of row marks in the garden, dig a hole deep enough to permit the plants' being set about three inches deeper than they were in the hotbed. Fill the hole up with soil and press it in firmly with the hands all around the plant. Water each plant thoroughly soon after planted. It is necessary that the soil be firmly packed around the roots of the plant, since, if the soil is loose, there will be air spaces left and the roots will dry out and the plant will probably die.

In a row by themselves set a few plants loosely without any firming of the soil. Watch for a few days.

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CHAPTER XXXII

PASTURES

A *pasture* is any land from which live stock gather feed for themselves. It makes no difference whether the areas are made by man or by nature, nor does it matter what the nature of plants may be so long as they are food plants.

Permanent and Temporary Pastures. An area naturally covered with the pasture crop or land continuously used for stock grazing is spoken of as *permanent* pasture. These permanent pastures are either range land—largely mountains in the West—or meadows.

The meadows and fields cared for by man, and renewed occasionally—regularly or irregularly—are *temporary* pastures. They consist either of fields left sown for a number of years or for one or two seasons, and of stubble fields.

Quality of Pastures. The best pastures are thoroughly and evenly covered with plants that form such sod as not to be injured by the tramping of animals or by their biting off the top of the plants. These plants ought to be palatable and fine to encourage the animals to eat a sufficient quantity, and nutritious in order that the quantity eaten may nourish the body and supply energy for their work whether drawing loads, growing wool, or producing milk. The pasture needs to be green a large part of the year and yield a large amount of feed.

Importance. About one third of all the improved farm land in the United States is in pasture. In the West, the range land exceeds several times in area the farm land, a part of which, perhaps a third or more, is temporary pasture. Many western valleys are so dry that they cannot be classed as grazing lands, although sheep feed over them and the arid foothills.

Immense droves of sheep and cattle formerly grazed over the intermountain region. The day of cattle kings is passing rapidly where it is not now already gone, but forest reserves still furnish pasture for almost countless horses, cattle,

Figure 97.—A picture of contentment. (Warren.)

and sheep. Grazing, however, lasts only during the summer. The animals removed from the range lands are turned into the mountain meadows and stubble fields to pick at the ungathered plant parts. Then they winter on meadows, supplemented with a partial ration of hay.

The convenience of a pasture in which to turn animals, especially during haying and harvest, is of considerable value. Much labor is also saved.

Wild Plants. Native grasses, together with rushes and sedges, largely compose these meadows. Sedges and rushes grow abundantly in the wet valley bottoms and sloughs. These supply much second-class feed on the wet lands. Salt grass and water grasses also grow in similar places making finer hay and better feed than rushes or sedges.

Bunch grasses, lupines, wild vetch, and numerous other plants are found on the ranges. Sheep get considerable grazing from sagebrush, shadscale, greasewood, oaks, chokecherry, and other green growing shrubbery.

Figure 98.—A woodland pasture. (Warren.)

Crop Plants. Kentucky and Canada blue grasses, timothy, redtop, smooth brome grass, orchard grass, tall meadow fescue, Italian and perennial rye grasses, tall meadow oat grass, and red, white, and alsike clovers are all used in temporary pastures. In addition to these, alfalfa, the small grains (with and without a mixture of peas, vetch, or cowpeas), corn, and millets are used to varying extent in different localities.

In general, these yield more palatable and more abundant feed than the native grasses, Except redtop, they thrive best on well-drained soils that are fairly rich in lime. Blue grass and the rye grasses need much moisture.

Mixed Plants. There are several benefits derived from mixtures for pastures. (1) They usually render more possible a continuous growth from early spring to late fall. (2) They usually increase the yield, as they can be made to feed in dif-

ferent soils or during different seasons of the year. (3) They render the feed more palatable on account of variety, and more nutritious particularly if the grasses have legumes sown with them. (4) The legumes aid in keeping up the fertility. (5) Deep rooting aids in loosening up the subsoil, thus promoting drainage and increasing available moisture. (6) A plant that establishes itself in one season, when mixed with one requiring two or more years, yields feed until the other can get well started.

Just what mixture to use is always a question. There are all variations within a given mixture, according to the land, to the animals pastured, and to the fancy of the owner.

The Utah Experiment Station reports these three mixtures of seed for sowing:

For bench lands under irrigation:

Kentucky blue grass	12 pounds	White clover	2 pounds
Smooth brome grass	8 "	Red clover	2 "
Perennial rye grass	6 "	Alfalfa	2 "
Orchard grass	3 "		

For light sandy soils under irrigation:

Kentucky blue grass	8 pounds	Smooth brome grass	8 pounds
Meadow fescue	12 "	White clover	2 "
Tall meadow oat grass	5 "		

For low, wet lands (as sloughs):

Perennial rye grass	8 pounds	Meadow fescue	2 pounds
Redtop	10 "	Alsike clover	5 "
Rhode Island bent grass	4 "	White clover	2 "

Various experiments on dry-farms show that smooth brome grass is the only successful pasture grass. Alfalfa is sometimes used for dry-farm pasture, particularly when either the first or second crop promises to be too small to pay for cutting. Many farmers turn the animals on stubble to gather remnants which would dry up and hence be lost by blowing away. Pastures on dry-farms seem to be more suitable for horses than for other animals.

For Different Animals. *Horses* do better on dry pastures than other animals, because they need rather large fields to afford exercise. They do not eat so close to the ground as to

injure the root crowns of alfalfa. They can also get on with less water than other animals, but need it regularly; and they do not bloat easily as do sheep and cattle.

Figure 99.—Rocky land can often be best used for pasture. (Warren.)

Cattle need a more succulent feed and more water than horses; therefore green pastures are more valuable, particularly for milch cows. As cattle eat rapidly, they bloat, especially on alfalfa wet with dew. Since horses worry cows, both ought not to be grazed in the same pasture at the same time.

Sheep do best on small pastures used in rotation, in order to keep down parasites. Shading is valuable to sheep, as is also fine feed. Resistant sod is preferable, as they eat close and injure the root of alfalfa and some grasses. If there are no trees in the field, sheds should be provided to give shelter from the sun.

Hogs do well on small pastures, because they require little food at one time. Shade and water in the feed lot are important. As soon as one lot is eaten off, the hogs should be moved into another, with abundant feed. They should not be allowed to waste feed by tramping it down.

Poultry also do better with access to green feed.

Improvement of Pastures. Land not easily handled in the regular cropping system is usually grazed. The rocky

Figure 100.—A stump pasture. (Warren.)

and very rough areas will, for a long time at least, be left in pasture, as not much else can be done with them. Removing many rocks is rather expensive.

Draining will much improve meadows that are too wet in the spring or throughout the entire season. Some spots may be too dry. A combination of drainage and irrigation can remedy this condition. Brush lands generally need partial or entire clearing before they become good pastures.

Rushes and sedges tend to give way slowly to the more valuable grasses after the lands are drained. Plowing and resowing may substitute this slow method.

The bunches of grass that occur everywhere are rejected forage around a spiny weed, such as a thistle, or around a manure dropping which seems to taint the grass or drive off the animals by its odor. Harrowing two or more times a

year with brush or spike-tooth harrows, or even disking, loosens the soil and scatters the manure. The harrow, supplemented by a grubbing hoe, removes the weeds that offend the cattle. Now, however, that Canada thistles have entered the mountain states, some attention ought to be paid to weeding pastures. They are very troublesome in sod, since they spread by underground stems as well as by seed. They are extremely hard to eradicate.

Poor stands may be made thicker by harrowing and by sowing extra seed.

Overstocking causes too close grazing, which injures the pasture as well as the animal. The remedy is manifestly one of prevention. Fertilizers, particularly farm manure, increase the yield, if they be well-scattered. In the West, however, few persons would advocate commercial fertilizers.

Constant use, even when unaccompanied by overstocking, is bad. Two or three pastures prevent this injury.

The number of animals that may pasture a field and the time they should feed on it deserve consideration. Strong sod will bear close grazing longer than weak. Timothy, orchard grass, and the clovers, except the white, suffer immediately. The blue grasses, redtop, the sedges, and the rushes are rather persistent and will withstand considerable close feeding. It is probably economical to graze firm sod closely, since bunches are thereby prevented and stalks not allowed to become tough from being mature.

Rotation. It is doubtful whether meadows should remain longer than a few years without being plowed. The plants weaken, the soil texture breaks down, and parasites may accumulate until the old sod is a menace. The most successful meadows are a part of the farm rotation. In its turn, every four to ten years, the meadow is moved to the advantage of the plant, the soil, the animal, and the farmer.

One meadow should not always be grazed by one kind of animal. Feeding habits differ enough to be a factor in

pasture management. With a large field, it is ordinarily better to use only part of it at a time and so to rotate the animals that they are not mixed. Dairy cows should not be worried by horses nor be in contact with the wallows of hogs.

A part of the pasture should be allowed to go unused at times. It needs a rest which permits the plants to grow up and keep green.

Parts of the meadow will not be eaten down, having bunches of coarse-stemmed grass. The mower should be run over these spots at least twice a year. The coarse stems make better hay than pasture. Often horses and cattle will pick up the clipped stems, although they avoid them while standing.

QUESTIONS

1. What is a pasture? Give kinds.
2. Why is sod needed in pastures?
3. Why does grass grow more rapidly after being nipped off than does alfalfa or clover?
4. Who owns the best pasture in your neighborhood? Describe it. What care is given to it?
5. Give the advantages and disadvantages of pasture mixtures.
6. Why do cows need a greener pasture than horses?
7. Why should pastures be on the poorer land?
8. Why is it good to rotate the animals for pasturing?
9. Why rotate the meadow? Does it always pay? When? When not?
10. Give the chief points to keep in mind in handling hogs and sheep on pasture.

EXERCISES AND PROJECTS

1. Visit a pasture. Are there any bunches in it? How might they be removed?
2. Examine a pasture in detail. Find the reasons for irregular growth. How large is the pasture? Have many animals pastured on it? What inexpensive improvements could be made? Are the gates in the best places? Is the fence properly cared for?
3. Visit good and poor pastures. Compare them.

4. Make a map of your neighborhood. Mark on it the pasture areas. Indicate the good and poor ones by different markings. Account for them.

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CHAPTER XXXIII

WEEDS

At the outset it should be remembered that in the plan of nature there is no such thing as a weed. As so often stated, every plant wars with every other plant for opportunity to live; it is a life-and-death struggle. It is only when we come to consider the plant in relation to man that the term "weed" comes into existence. If it could be realized and appreciated that in nature each plant plays its part and each has its aesthetic characters, weed extermination would hardly be carried on by man in the sullen spirit often seen.

What Is a Weed? A weed may be designated as a plant which is deemed undesirable. "It is a plant out of place." Other designations of weeds are: "Any injurious, troublesome, or unsightly plant that is at the same time useless or comparatively so." "A plant which interferes with the growth of the crop to which the field is temporarily devoted." Accordingly, barley plants in the wheat field, wheat plants in the barley field, if not wanted, must be designated as weeds. Furthermore, it is to be remembered that a crop may be a weed unto itself. Often the producer has too many plants standing on a certain area for the best yield. The apple, the pear, the peach tree are seen often so heavily loaded, that one individual fruit acts as a weed to the other. Why is the fruit thinned by the wise horticulturist?

Injury Done by Weeds. The injuries by weeds are many and of various kinds. Among the injuries produced may be mentioned the reduction of soil fertility. Plant foods that are needed for the crop are in part used by the weeds; the result is a lessened yield. Another serious injury is that of robbing the soil of the moisture which is necessary for crop

production. When it is realized that a corn plant, according to Haberlandt of Germany, may transpire, during a single growing season, 30 pounds of water, a hemp plant 60 pounds, and a sunflower 135 pounds, some idea is gained as to how much water may pass from the soil through plants. According to Dr. Duggar, one of the foremost plant physiologists of the United States, the amounts given are in general too low for conditions in our own country. If this statement is accepted, then how much too low must the figures be for conditions in the arid West?

Figure 101.—A Russian thistle.

Weeds also exert injury by crowding and shading, thereby causing the plants of the desired crop to grow slender and abnormally small. The presence of some kinds of weeds makes the harvesting of the crop very difficult and expensive. Such weeds are the dreaded Russian thistle, which is becoming all too abundant in the arid West, the wild buckwheat, and the wild morning-glory. Other weeds are very noxious, because they harbor parasitic fungi that attack the cultivated crop. Such are the mustard, which harbors the organism causing clubroot of cabbage, and the white rust of radish and salsify. Some weeds are poisonous to man and animals, while others give

the animal trouble in eating. An example of the latter is the common squirreltail, the awns of which enter the gums of animals and cause ulcerations.

Duration. By duration is meant the length of life of the plants. Weeds classified under this head are annuals, winter-annuals, biennials, and perennials. *Annuals* are plants that have but one growing season, such as cowcockle, sunflower, Russian thistle, and cocklebur. *Winter-annuals* are such as the common shepherd's-purse whose seeds germinate in the fall, the plant completing its growth the following spring and summer. *Biennial* weeds are those whose existence embraces two growing seasons. The first season the plant produces only root, stem, and leaves, while the second it produces flowers and fruit. Common examples are the bull thistle, wild carrot, and burdock. Such weeds never appear in lands properly cultivated and plowed every year. *Perennials* live more than two years. They continue to produce seed year after year. Common examples are the morning-glory and the dandelion.

Dissemination of Weeds. By dissemination is meant dispersal, or scattering. It is readily seen how important it is to the existence of the weed that this should occur, if we remember that the mother plant has been absorbing food material from the soil during its growth and development and has probably given off poisonous substances from its roots, all of which go to make the soil more or less unfavorable, temporarily at least, for the production of more plants of the same kind. Hence, if the seeds are disseminated to new regions, the chances for survival are better and thus a weed is not very likely to become a weed unto itself.

The dissemination of weed seeds is accomplished by various agencies, some of the most important of which are wind, water, animal, and man. It is common to see dandelion and milkweed seeds floating through the air, wafted here and there by the breezes. Every country boy has often seen

piles of tumble weeds heaped up along some fence row. It is almost inconceivable how many seeds have been scattered as the plants rolled along the way. When it is recalled how wild oats spread from field to field, and how the sweet clover and cocklebur spring up along the ditch banks, good illustrations are shown of the work of water in scattering weeds.

Figure 102.—Field bindweed.

One who has occasion to remove burs of the cocklebur and burdock from the hairy coat of the dog, or from the horse's mane and tail cannot fail to appreciate how effective animals may be as carriers of weed seeds. Animals, however, are also very effective in weed dispersal in a manner usually not so evident as illustrated above. They eat seeds which are not digested and which pass through the alimentary tract without injury. Often by this method weeds are carried great distances into new regions.

Man himself is fundamentally very much at fault as an agent in weed dispersal. The tools with which he works his land, the machines that do the threshing and other crop work are often taken from field to field uncleaned. Morally speaking, man himself is very much to blame for present conditions, in that he buys and sells impure seed. Seed of

some particular crop is purchased in some other state and with this seed it is not uncommon to find many other seeds present, some of which are persistent weeds. The grower takes no notice of these, and only a year or so follows until he realizes that a serious drawback to a good crop lies in his own careless actions. The condition can be remedied only by greater watchfulness and care on the part of both the producer and the seller.

Figure 103.—Mustard.

Weed Laws. Laws may be and should be passed for the destruction of weeds, but the farmers should not fail to appreciate that they can do much themselves by concerted and energetic action. Weed laws should embrace a number of important points and should be passed only after careful consideration. Laws, under some circumstances, give no help but have a tendency to suppress local efforts in farming communities. Inspection of seed would do much to improve weed as well as seed conditions. Rural high schools and farmers' organizations might do much good by a little wisely directed effort.

Extermination. In extermination, any method adopted must depend upon the nature and habit of the plant, the soil, and the location. All annuals may be destroyed in cultivated lands by any method which hastens germination and prevents seeding. Biennials should be cut off below the crown. Where plowing is impossible, mowing may be resorted to, but usually the plant will be induced by this

method to shoot out and become more troublesome, providing repeated mowing is not continued. The perennials are, generally speaking, the most troublesome of weeds. This fact is due to the peculiar habit of many to produce roots and underground stems, which, when severed, will produce a new plant. A single plowing often makes the weeds in this class more pernicious. We must here resort to special methods. For details of which one of the weed manuals listed at the end of this chapter should be consulted.

One of our specialists on weeds has tersely given the keynote to weed extermination under the following few general principles:

1. There is no weed known which cannot be eradicated by constant attention, if the nature of the growth is understood.
2. Never allow weeds to ripen.
3. Cultivate frequently, particularly early in the season, so as to destroy seedlings.
4. Many weed seeds can be induced to germinate in autumn by cultivating stubbles immediately after harvest. Most of these seedlings will be winter killed or can easily be disposed of by plowing or cultivating in the spring.
5. All weeds bearing mature seeds should be burned. Under no circumstances should they be plowed under.
6. All weeds can be destroyed by the use of ordinary implements of the farm—the plow, the cultivator, the harrow, the spade, and the hoe.
7. Be constantly on the alert to prevent new weeds from becoming established.
8. It might also be added that it is often advisable to practice rotation of crops, and also to destroy weeds by the use of herbicides.

Spraying. Much experimentation in extermination of weeds by herbicides has been carried on both is this country and in Europe. Success has followed in some cases.

Some of the most successful herbicides together with their proper usage are as follows:

Copper Sulphate (blue vitriol), 12 pounds to 50 gallons of water. Spray in dry weather. This spray destroys leaves of burdock, prickly lettuce, common mustard, prostrate pigweed, and goosefoot.

Iron Sulphate (green vitriol), 100 pounds to 50 gallons. Spray before weeds are in bloom. This spray destroys dandelion, dooryard knotgrass, purslane, yarrow, sorrel, large ragweed, hedge mustard, sourdock, smartweed, mustard, velvetleaf, small ragweed, lamb's-quarters, peppergrass, sow thistle, bull thistle, wild carrot, pigweed, shepherd's-purse, and spurge.

Carbolic Acid. One part to four parts water. Thoroughly agitate. Use along walks. This spray kills pigweed, smartweed and pigeon grass.

For further details on the use of herbicides consult Pammell's "Weeds of the Farm and Garden."

QUESTIONS

1. What is a weed?
2. How do weeds injure crops?
3. Classify them.
4. In what ways are weeds spread?
5. Discuss weed laws.
6. Give the best methods of exterminating weeds.
7. Give the principal points concerning spraying to kill weeds.
8. List the common weeds of the neighborhood.
9. Wherein may weeds be beneficial?

EXERCISES AND PROJECTS

1. The instructor will mix up one or two gallons of one of the spray mixtures given on this page of the text. Obtain a small hand sprayer and spray a plot of ground that is covered with weeds. Note the kinds of weeds and record the effects of the spray. Tabulate the results.
2. Dig up by the root some Canada thistle, morning-glory, or other weed that spreads underground. Note that on the root stalks

are buds. These send up new stems. Compare these with the roots of annual weeds.

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660. Weeds: How to Control Them.

CHAPTER XXXIV

PLANT DISEASES

When is a plant said to be diseased? If a plant which varies from the ideal is regarded as diseased, then nearly every plant is diseased; for the factors which determine growth are usually not ideal. Disease, however, is usually made to embrace any striking variation such that the life of an organ or sometimes the life of the plant as a whole is threatened. All gradations exist between that which is called disease and that which is regarded as health.

CLASSIFICATION

I. Germ diseases caused by:	II. Non-germ diseases caused by:
(1) Slime molds	(1) Lack of water
(2) Bacteria	(2) Excessive water
(3) Fungi	(3) Alkali
(4) Flowering plants	(4) Smelter smoke

How plants are injuriously affected by lack of water, too much water, alkali, etc., is given where the study of crop production in relation to water and soils is considered.

Germ diseases are those in which a living plant (the causal organism) lives upon another living plant, the host, and brings about those abnormal conditions which result in a marked decrease of vitality and in premature death. The causal organisms have accustomed themselves to obtain their carbohydrates from other living organisms and are hence called parasites in opposition to those organisms called saprophytes which obtain their carbohydrates from dead organic matter.

SLIME MOLD DISEASES

The diseases caused by slime molds are generally of little significance in the arid West. Occasionally, however, where cabbages are grown, one of these diseases known as the club-root of cabbage and other crucifers arises.

Clubroot of Cabbage. *Hosts.* Some of the plants which become diseased by the slime mold organism are cabbages, cauliflowers, Brussels sprouts, turnips, rutabagas, radishes and certain mustards. There seems to be little information as to the relative susceptibility of different varieties of crucifers to this disease.

Figure 104.— Clubroot on cabbage. Losses from this disease have often been disastrous.

Symptoms. Seedling plants show a decided wilting or flagging. They are stunted and have an unhealthy appearance. Most seedlings attacked die. When older plants are attacked, the first indication of disease is a decided wilting during the heat of the day which is overcome during the night when transpiration is less rapid. This condition is brought about by the organism which has invaded the root tissue and caused excessive and abnormal growth in the phloem and cortex regions at the expense of the xylem region, which is the water conducting tissue of the plant. The clubbing of the roots is very characteristic. The roots are greatly enlarged at the base while toward the tip they appear normal. Curious malformations are likely to occur.

Control. The disease cannot be cured; so, the only course of action must be prevention. The following rules are applicable:

1. Avoid all those conditions which favor disease, such as lack of clean cultivation, manuring before planting, and poorly drained lands.

2. Where cabbage is fed to animals it should be cooked beforehand to destroy the organism or otherwise the spores will pass through the alimentary tract uninjured.

3. Deep plowing should constantly be the rule.

4. Since the organism preys upon various crucifers, rotate crops. In the rotation, crops not of the cruciferous kind should be used.

5. Clean soil should always be in the seed bed. To obtain this always sterilize with steam or with formalin.

6. When soils are acid, liming should be practiced. Use 75 bushels of air-slacked stone lime per acre.

Figure 105.—Fire blight on pear tree.

BACTERIAL DISEASES

The two most disastrous bacterial diseases are all that can be studied in this short chapter, although more than one hundred and twenty-five are known.

Pear Blight. ***Hosts.*** The plants usually attacked are pear, apple, and quince. The germ also attacks hawthorns and plums. Of the pear, such varieties as Bartlett, Flemish Beauty, Seckel, and LeConte are more susceptible than are such as the Kieffer, Duchess, and Winter Nelis. The disease, while usually not as disastrous on apples as on pears, often becomes quite serious.

Figure 106.—Fire blight on an apple tree.

Symptoms. Body blight, or canker, shows itself as diseased areas in the bark of the body or the large limbs. When the disease is active, these cankers are of a dark water-soaked appearance and the advancing margin is indefinite, or raised and blistered, with or without ooze of reddish brown drops issuing from the lenticels. When the canker is no longer active, it has a definite margin. It is then separated from the healthy tissue by a crack. These cankers form about the base of a blighted shoot or spur. They are the means by which the disease is carried over winter. Blossom blight is evidenced by sudden wilting and blackening of the young fruit shortly after the petals fall. Then follows wilting and blackening of the young leaves of the spur. This form of blight is disseminated by insects or other small animals which visit the ooze containing the blight organism which is found on the edge of the active cankers and carried to the blossom. Twig blight shows as a sudden wilting and blackening of the young twig from the tip downward. Fruit blight shows as a water-soaked area on the green fruit which blackens. From the lenticels of the fruit milky drops containing the bacteria ooze out.

Figure 107.—Twig blight on apple.

Control. The remedy for this disease lies in cutting out infected areas. The disease may generally be controlled. If all growers knew the various stages of the disease and were very vigilant in attempting to free the orchard from it, the disease could practically be eradicated. All withered growth that shows evidence of the blight should be pruned out before blossoming time.

Figure 108.—Crown gall on beet. It is found on fruit-bearing, flowering, and vegetable plants.

Summer pruning is also practiced. Wherever blight is cut out the excised material should be carried from the orchard and burned. All wounded areas made during the winter or summer should be well washed with a solution of 1 part of corrosive sublimate to 1,000 parts of water. If care in pruning is not exercised and the wound is not sterilized, the disease may be spread rather than controlled when pruning is attempted.

Crown Gall. *Hosts.* Grapes, raspberries, peaches, apples, pears, pecans, and many other plants, both cultivated and wild, are attacked by crown gall. The organism may live in the soil and be carried by irrigation water. Nursery stock is a very common means of dissemination. Older trees are less likely affected.

Figure 109.—Crown gall on peach tree.

Symptoms. It is chiefly characterized by galls or swellings on the crowns or roots. The galls may be smooth or rough—usually rough—and hard or soft. At times the roots throw out tufts of smaller roots, whence the name "hairy-root." The galls vary in size from small on small roots to large on large ones.

Control. Avoid planting any nursery stock which shows any signs of disease. Healthy trees should not be planted in soil already infected. Trees planted should be healed over as much as possible and in cultivation care should be taken that few wounds on the underground parts of the tree are produced. It is difficult to remove successfully the diseased portions. Control is, therefore, rather a matter of prevention than of cure.

FUNGOUS DISEASES

Fungous diseases are more numerous by far than bacterial diseases. Only a few of the principal types, however, can receive consideration.

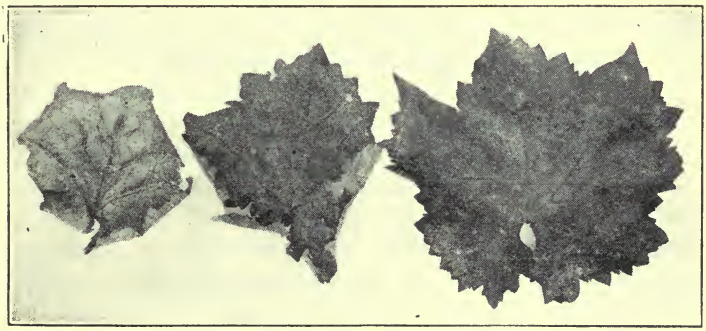

Figure 110.—Gooseberry leaves affected with mildew.

Gooseberry Mildew. *Symptoms.* This disease is characterized by the white or gray patches of mildew upon leaves, stems, and fruit of the gooseberry. Occasionally it is found attacking the currant bushes.

Control. The best results so far obtained have been by the use of a solution of potassium sulphide, 1 ounce to 2 gallons of water. Spraying should begin at the time the buds burst in the spring and be repeated every 10 days, if the fungus is present in considerable quantities.

In general the mildews are very similar in appearance and readily identified. The treatment usually consists in the use of some sulphur or sulphide spray which is applied throughout the season every two weeks, if conditions require. Some of the most destructive mildews are those of the peach, the apple, and the grape.

Figure 111.—Common potato scab.

Potato Scab. *Symptoms.* Scab first shows by a minute reddish or brownish spot on the surface of the potato tuber, generally when it is very young, though sometimes not so early. After it has once appeared it may extend quite rapidly to the surrounding tissue, becoming deeper in color and being associated with an abnormal corky development which often covers a considerable area. This area may constitute a more or less irregular scab-like crust over the surface, or more frequently may become deeply cracked, depending upon the stage at which the tubers first become diseased. Those which are attacked while very young show, as might be expected, by far the most deeply seated injury.

Control. The methods of control are of two natures, treatment of the seed and of the soil. In general the only soil treatment resorted to is liming the soil where it is somewhat acid (an acid soil favors the growth of the organism), and to practice a judicious rotation of crops.

When the grower has a large quantity of seed to treat he may store it in crates in a tight cellar or compartment in such a way that the air can circulate freely between the crates. To every 1,000 feet of air space 23 ounces of potassium permanganate and 3 pints of formalin should be used. The potassium permanganate is placed in a large receptacle, as a tub, and the formalin poured quickly over it. Rapidly tilt the tub first to one side and then to the other, so that the formalin covers the potassium permanganate. Then leave the room instantly and close the door. Formaldehyde is generated, which circulates throughout the compartment, disinfecting and killing the germ in the scab spot. Allow the potatoes to stand over night or for the period of about 12 hours. Then open the door and allow the formaldehyde to escape.

For small quantities of potatoes use 1 pint of formalin to 30 gallons of water and immerse the potatoes in this solution for from 1½ to 2½ hours. Remove after this period and dry. In place of formalin, bichloride of mercury (corrosive sublimate), 1 pound to 125 gallons of water, can be used. This solution should be made up in a wooden barrel. It is very poisonous to man and all other animals.

Finally, plant clean seed in soil as free from the disease-producing germ as possible. To obtain the seed use a small seed plat.

The potato is one of the most extensively diseased of crops. No less than ten very serious diseases have been studied. Their close similarity of symptoms in so many instances makes it impossible to study them to advantage without microscope and laboratory facilities.

Covered, or Stinking, Smut of Wheat. This disease is caused by two separate species of fungi which are so nearly alike in their appearance and whose effects upon wheat are so similar that, when speaking of stinking smut, both fungi are regarded as one.

Symptoms. The affected heads are of somewhat darker green color than normal, or healthy, heads and the individual spikelets are somewhat smaller and a little farther apart.

Always associated with the disease is a disagreeable odor which gives the disease the name "stinking" smut. The

Figure 112.—Stinking smut on wheat.

place usually occupied by the kernel is now occupied by the smut spores. These remain enclosed by the ovary walls and glumes; hence the name "covered" smut.

Control. Control is secured by treating the grain with a fungicide. The principal fungicides so far in use have been formalin and blue vitriol.

In the formalin treatment, the seed may be put in sacks containing one half to one bushel each, and then be immersed from 10 to 30 minutes in a solution containing 1 pint of formalin to 50 gallons of water. At the end of the allotted time drain the sacks over the barrel for a short time and put away the wet sacks or heap the grain and cover it. Let the grain stand in the wet sacks or lie in the heap for two hours, then

spread out and dry. Shoveling over the grain will facilitate the drying.

When using the blue vitriol, use 1 pound to 4 gallons of water and immerse the wheat for 5 minutes. Then remove and dry. Somewhat more seed should be used than when sowing untreated wheat, as the germinating power of the grain is reduced about 15 per cent.

It does not follow that treating grain will produce a crop absolutely clean. The smut spores may probably live in the soil at least one season and affect in many instances seed that has already been treated; thus the crop may be somewhat smutted.

After seed is treated, use clean sacks and a clean drill.

DISEASES CAUSED BY FLOWERING PLANTS

There are a great many diseases caused by flowering plants. Two of the most common diseases of this group in the West are those caused by the mistletoes on the conifers and junipers, and the dodder on the alfalfa and clover. The mistletoes are of considerable interest to the forester, while the dodder attracts the attention of the farmer.

Dodder. ***Hosts, Symptoms, etc.*** The dodder attacks clover, alfalfa and many other plants. It grows from the seed as a long, slender, yellow filament which sways in the air until by chance it comes in contact with the host plant. Thereupon it twines itself about the host, sending *haustoria* into the bundles where water, salts and organic food are obtained for its growth. After attachment has finally occurred the dodder no longer has use for its roots which, in turn, die and the plant is then entirely dependent on the host. After seeds have been produced the dodder dies. The seeds lie on the ground until the following spring when the same story is repeated. Providing the dodder filament produced from the seed does not come in contact with the host, it perishes, as it is unable to sustain itself upon food material derived

directly from the soil. Alfalfa and clover plants become exceedingly dwarfed under severe cases of the disease and mostly become valueless as a fodder crop.

Control. The seed of the parasite resembles the alfalfa or clover seed and is, therefore, easily disseminated with it. Great care should be taken to purchase clean seed. Diseased areas in the field may be burned when covered with straw upon which kerosene should be sprinkled. Rotation of crops yields very satisfactory results.

QUESTIONS

1. When is a plant diseased?
2. State the causes of plant disease.
3. Name several of the most common plant diseases.
4. Describe pear blight. Give method of control.
5. Do the same for crown gall, gooseberry mildew, and wheat smut.

EXERCISES AND PROJECTS

1. *Crown Gall:* Collect samples of plants attacked by the crown gall organism. Note the general appearance of the gall. Note the cracks and ridges. Is the gall hard or soft? Sometimes secondary galls appear farther up on the tree. Do any of the samples of the crown gall show any deformity of the root system? What is the cause of "hairy root?" Draw.
2. *Pear Blight:* If conditions are favorable, this should be a spring field trip. Visit some pear or apple orchard where the blight is to be found. Look on the trunks or branches of the trees for sunken areas, the "hold-over" cankers. What is their function? See if you can find honey-like drops oozing out. What are these drops? The blight also attacks the blossoms, young twigs, and young fruit. How can insects help to carry the disease to the blossoms of young twigs? How can you tell how far the blight has advanced on a young twig? Do the trees show any signs of the fruit's being blighted? Draw.
3. *Covered, or Stinking, Smut of Wheat:* Examine a head of wheat affected with stinking smut. Compare a diseased head with a normal head. Note differences in color, shape, kernel, etc. Make drawings showing these differences. Mount some spores in a drop of water and examine under the microscope. Note color, size, etc. Draw.

4. *Powdery Mildews:* Study any available powdery mildew such as that on grasses, doorweed, willow, gooseberry, etc. Examine the affected plant both in the field and in laboratory. What part is affected? What injury occurs to the host?
5. *Potato Scab:* Secure specimens of potatoes diseased with scab. The disease may show as a scab-like crust over the surface, or it may become deeply cracked and furrowed. Study until you become so thoroughly acquainted with the disease that you can detect it.
6. *Dodder:* Secure samples of dodder or take a field trip to some place where it can be observed growing. Note the general appearance of the attacked plants as compared with the healthy plants. Note the way in which this parasite attacks the host. Write the life history of dodder.

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CHAPTER XXXV

CONTROL OF INSECT PESTS

An insect is an invertebrate animal possessing three main divisions of the body: A *head* which contains the mouth parts, eyes, and antennae, or feelers; a *thorax*, to which are attached three pairs of legs and usually one or two pairs of wings (some insects never have wings); and an *abdomen*, the posterior end of which contains the reproductive organs. Insects breathe by means of trachea, which are finely divided tubes passing all through the body and reaching the outside by small openings on the abdomen and on the thorax. The blood circulates freely through the body, supplying the insect with the oxygen necessary to continue its life.

Feeding Habits. Insects have two types of mouth parts —biting and sucking. Of the biting insects, grasshoppers, beetles, and caterpillars are best known. Among those insects which secure their food by sucking are the true bugs, the leaf hoppers, and the butterflies and moths.

Not all insects are injurious: many should be protected. We usually do protect the honey bee and the silk worm. There are other insects that pass their lives preying upon their fellow creatures, and still others that lay their eggs inside of other insects, their young feeding inside of the host and eventually killing it. It is well, in studying insects that are supposed to be injuring crops, to take into consideration these facts; to examine the insect and find whether it is really doing damage, and, if it is, whether that damage is done by sucking the sap or juices of the plant or whether it is caused by the insect's actually chewing up the leaves for food.

In no country has the loss by insects been heavier than in the United States. It has been conservatively estimated

that the present loss reaches one billion dollars annually. Cultural methods and the proper use of spraying and other insecticides will save to every man a large part of this loss.

Codling Moth. As a typical example of an insect that feeds by chewing its food, and that is controlled by feeding it a poison, we may take the larvae, or young, of the codling moth, the apple worm. This insect causes more damage than all other apple insects in the intermountain region. The worms pass the winter in tough cocoons, hidden in the rough bark on the trunk or larger limbs, under rubbish in the orchard, or in fruit cellars. In the spring they change into the pupa, or resting, stage and later are transformed into moths. These moths, which are nearly the color of the apple bark, come out from ten days to two weeks after the blossoms fall and lay their eggs on the apple leaves or on the apples, where the fuzz has been rubbed off, or where two apples are touching. The great majority of these worms, when they hatch, go in at the calyx, or blossom end of the apple. At this point there are very few hairs and the worm can obtain an easy entrance. They remain in the apple from twenty to thirty days, bore their way to the outside, crawl down the tree, hide away, spin their cocoons, and pass into the resting, or pupa, stage. In ten to fourteen days, a second brood of moths appears. The eggs of this second brood are usually laid on the apples, the larvae, when hatching, eating in at the side *or any other* point on the apple. When these worms are full grown, they leave the apples, go down the tree, and spin the tough cocoons in which they live over winter. Many of the worms are not full grown at the time of apple picking and so are carried into the fruit cellars or crawl out of the apples while they are lying on the ground.

It will be noticed from the above that the first brood of worms usually goes in at the blossom end of the apple and that they are not present on the trees until after the apples have formed. At this time the blossom end of the apple is so well

closed up by the little leaves which surround it, that any spraying for the codling moth *must be done before the worms are present* in the orchard.

Spraying. The accepted time for spraying is immediately after the blossoms fall from the trees. In looking at an apple tree, we find that the blossoms on the tree always point towards the light. Thus blossoms are pointing outward in every direction. In order to get poisonous compounds into this blossom end, it will be necessary to use considerable pressure and drive the spray into the partly closed cup. The spray to use is *lead arsenate*, at the rate of two pounds to fifty gallons of water. Use a Bordeaux nozzle, driving the spray directly into the center of the blossom end. Pay no attention to the leaves on the tree. Look only for the blossom ends and put the spray there. One hundred pounds pressure or more is necessary to do the work. It is necessary to have a tower or ladder on a wagon so that one can get above the blossoms that are pointing upward. A bamboo rod, attached to twenty-five feet of good seven-ply hose having at the nozzle end of the rod a 45-degree angle to which the nozzle is attached will aid in doing this work properly. *Do thorough work.* Do not miss a blossom. The nozzle should be kept moving up and down the branch all the time. It is ordinarily a wise precaution to repeat this spraying ten to fourteen days later in order to poison the cups of the apples that were not ready at the time of first spraying. If the orchard is badly infested or close to badly infested orchards, it may be necessary to spray for the second brood about the first week in July with a mist spray, endeavoring to cover the apples with the spray. In any case put burlap bands around the trees about a month after blossoming and remove these bands every ten days, killing the worms that appear under them, until about the 20th of August. Then the bands need not be removed until after the apples are picked, when they should be taken off, the worms under them

killed, and the bands put away for the next year. The bands should be made of pieces of burlap which are one foot wide, folded down four inches from the top, and put around the tree with the long flap on the outside and fastened with a tack.

Among other insects which may be handled by arsenate of lead spraying are the pear and cherry slugs, the tent caterpillar, the fall webworm, and the sugar-beet caterpillar. The leaves of trees or plants affected with these insects should be covered with a mist spray.

Scale Insects. The sucking type of insect requires an entirely different method of treatment. With scale insects, which belong to the sucking class, it is often necessary to spray in the winter time, using what is known as the lime-sulphur wash. These insects at this time are on the trees, covered with the cast-off skins and a waxy secretion, which make what is called the scale. In early spring, in the case of the San Jose scale, which works on all our fruit trees, the young are born alive, and in about twenty-four hours commence feeding, the females probably never leaving the spot when they begin feeding. There are several generations during the summer. The scale protects this insect so effectively that it is very hard to put on the tree while it is growing anything that will be strong enough to penetrate the scale and still not injure the leaves and fruit; hence we are practically restricted to winter work.

Spraying. The lime-sulphur wash may be a homemade preparation. Use 15 pounds of sulphur and 20 pounds of lime, to 50 gallons of boiling water. This is best prepared by having about 5 gallons of boiling water, adding the lime in small lumps and following this immediately with the sulphur. It will be found necessary to stir this mixture rapidly for some time to keep it from boiling over. It is sufficiently cooked when it stops changing color and may then be diluted down to the necessary 50 gallons. In using the prepared or manufactured lime-sulphurs, in the case of

those that contain water, they should be so diluted that they are no weaker than one to six. The powdered lime-sulphurs which are now on the market will certainly be cheaper so far as the transportation of the materials is concerned, and should be used at the rate of 15 pounds to 50 gallons of water. It is always best to use a hydrometer to test the strength of lime-sulphur compounds. In using lime-sulphur care should be taken to cover every part of the tree which is being sprayed. If necessary, go over it two or three times so that all of the tips of the twigs and the crevices in the bark are thoroughly covered. This mixture will aid not only in controlling scale insects, but will also kill the eggs of the *aphids* or plant lice, and those of the brown mite, or red spider, which are laid on the apple and other fruit trees.

If by any chance lime-sulphur spray has not been given to trees that are heavily infested with the eggs of plant lice, when these insects hatch they must be controlled as early as possible. When leaves are just well opened, good results will be obtained by spraying with a *tobacco mixture* using one of the sheep dips of the strengths recommended in the printed directions, and driving the spray up from beneath so that it will strike the under side of all the leaves where the plant lice are feeding.

Arsenic Bran-mash. There is one other insecticide that is in general use, a mash for poisoning insects such as grasshoppers in fields and orchards, and cutworms in gardens.

The arsenic bran-mash consists of a preparation of 1 pound of white arsenic, 4 to 6 pounds of sugar, and 12 to 20 pounds of bran and 3 oranges or lemons. Mix these dry, then dampen sufficiently to cause the sugar to stick to the bran and to hold the arsenic. Grind or cut up the fruit and mix thoroughly into the mash. This may then be sown broadcast along edges of fields where grasshoppers are coming in, or scattered in small piles around trees or in gardens

around plants that may be injured by cutworms or grasshoppers. Keep chickens away. This mixture is poisonous.

Cultural Methods. Among the general means of control of insects, it must not be forgotten that the most important is clean culture—the destruction of all the weeds, rubbish, and other trash in and around fields, houses, barns, and other buildings. Crop rotation is also necessary; especially is this true in the case of the alfalfa weevil, an insect which lives entirely by feeding on the leaves and stems of plants in the alfalfa group. Alfalfa should not be grown on the same soil more than four or five years at a time. If the fields are infested with the alfalfa weevil, the land should be thoroughly cultivated in the spring or fall, using a disk or spring-tooth harrow. This cultivation will also aid in getting rid of grasshopper eggs. As soon as the first crop is removed, the land should be gone over with a spring-tooth harrow and followed with a heavy brush or wire drag. By this means many of the larvae or young of the weevil will be crushed or otherwise injured. The most of the leaves and buds will be pulled from the stubble and the alfalfa-weevil worms which are remaining in the field will have nothing upon which to feed. One day of hot sunshine will then kill a large percentage of them.

QUESTIONS

1. What is an insect? Distinguish between insects, red spiders, nematodes, and sow bugs.
2. How would you distinguish between injuries caused by biting insects and sucking insects?
3. Why is it necessary to put the first codling moth spray into the calyx cup?
4. Why may the calyx cup be neglected with the second spray?
5. Why are cultural methods of control, where possible, preferable to other methods?
6. How would you protect parasitic or predaceous insects from destruction?
7. Why is it necessary to study carefully the life history of an insect before it is possible to ascertain the best method of control?

8. Of what value are birds to the general farmer?
9. Why should the English sparrow be destroyed?

EXERCISES AND PROJECTS

1. Schools should use insects in the particular region where they live for illustration. Plants can be kept in the schoolroom and insects, such as aphids will readily multiply upon them. Caterpillars and other biting insects may be kept in small boxes and fed daily with their proper food. Study insects in the field in order to gain knowledge of their habits.
2. Visit an apiary and study the honeybee at work.
3. If in a farming neighborhood visit some up-to-date farmers and see them in their work of controlling such insects as codling moth, San Jose scale, or alfalfa weevil.

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909. Cattle Lice and How to Eradicate Them.
940. Common White Grubs.

CHAPTER XXXVI

BEEF CATTLE

Domestic cattle originated from two wild types, one from which European and American cattle are derived, and the other the humped cattle of India. In early European history two types were known, one a large type sometimes called the great wild ox, from which evolved the larger breeds of cattle; the other type, smaller and more deer-like, from which came the smaller breeds of cattle.

Meat Production. Meat forms a large part of the food of the white races, and, therefore, meat-producing animals occupy a very important part of the agricultural interest of the world. There are on earth nearly three hundred million cattle that may be classed as meat-producing; hence the United States, owning more than forty million, produces more than one eighth of the world's beef. Meat is not, as formerly, all consumed near the place where it is produced; but, as a result of modern methods of transportation, is shipped to all parts of the world.

Beef Type. In general a beef animal should show the meat-producing form, which is found in a low-set, blocky, deep, thick animal, having a large percentage of edible meat. The ideal beef animal has straight back (topline) and straight underline, and he stands on short legs. Cutting off head and legs leaves a square block of beef.

The Feeder. Feeders, or store cattle, are those in thin condition, which lack finish and must be fattened before slaughter. Feeders should conform to the general beef type, as the lower-set, blocky ones gain faster. A good feeder should have a short, broad head, a strong jaw, a wide muzzle, and large eyes and nostrils, a wide back and loin, a deep rib,

and a long, deep hind quarter. Long-headed, narrow-chested, high-flanked steers do not make satisfactory gains and are not desirable as feeders. Rather fine bone, loose skin, and silky hair are preferable, since they denote quality.

The Fat Animal. The finished animal should have the low, blocky form mentioned, with the short broad head and

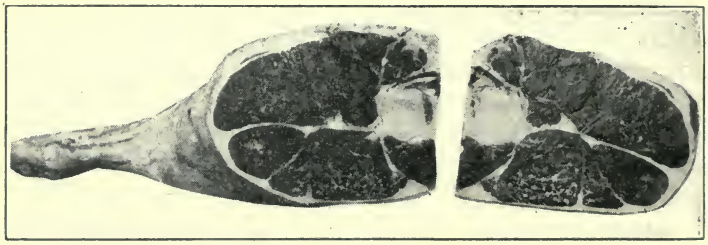

Figure 113.—Good beef—the round.

the quality of the feeder, carrying a good proportion of meat in the regions of the valuable cuts. The neck should be short and thick: the shoulders, smooth; the chest, deep and full; the back, long, broad, and deeply fleshed; the loin, broad and thick; the hind quarters, long, full and deep, the meat being carried well down to the hocks. An animal of the above type will give a good carcass of first-class meat, when dressed. Good meat is bright red and shows traces of fat through it.

The Carcass. One of the principal concerns of the butcher is the killing or dressing percentage, that is, the proportion of meat to live weight. Cattle dress out all the way from fifty to sixty-nine per cent, though the latter is a mark very rarely reached.

There is a great difference in the value of the different cuts of meat. The best cuts are found in the back and hind quarter. The back furnishes the rib roasts; the loin, the sirloin and porterhouse, or T-bone steaks; the rump, the tip roasts; the thigh, the round steak. From the neck, shoulders,

brisket, and flanks, come the cheaper cuts of beef used for boiling pieces, stews, soup, and sausage. The tenderer parts of the beef bring the higher prices.

BREEDS OF BEEF CATTLE

Shorthorn. The Shorthorn cattle, once called Durham, originated in eastern England along the Tees river in the

Figure 114.—Champion two-year-old Shorthorn cow.

counties of Durham and York. The native cattle were good grazers, and by selection among these and by the introduction of some cattle from Holland, the Shorthorn breed was developed. This is one of the oldest breeds, having been improved since about 1600.

In color, the Shorthorns are mixed, being red, white, or roan, or a mixture of these. The roan is the only characteristic color. In size, Shorthorns are among the largest of cattle, bulls often weighing over a ton and cows from

1,400 pounds up. Shorthorn cattle should be low-set, blocky, and broad-backed. As a breed they are squarely built with a heavy hind quarter and great width of loin. These cattle have a clean-cut head and show considerable quality, style, and finish.

Doing well under a great variety of conditions, they are the most widely distributed of any breed. Under range

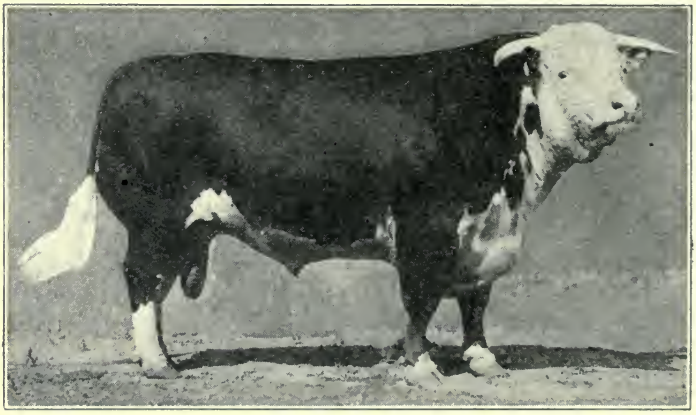

Figure 115.—A prize winning Hereford bull.

conditions Shorthorns do very well and so they are popular in the West. As milkers they surpass all other beef breeds, some of them being very satisfactory at the pail. To a Shorthorn cow belongs the distinction of having been the highest priced bovine ever sold, up to 1915, $40,600 having been paid for the Eighth Duchess of Geneva.

Polled Durham. The Polled Durham is an American breed developed from the Shorthorns, differing from them only in the absence of horns. This breed is rather popular in sections of the East, but little known in the range states.

Hereford. Herefordshire in western England is the home of the Hereford cattle. This breed was developed at about

the same time as the Shorthorn, dating back to the sixteenth century. The ancestors of Hereford cattle came from the native cattle of England with probably a few additions from the Flanders and Holland cattle.

Hereford cattle are very uniform in characteristics; in color, for instance, they are red with white faces, white along

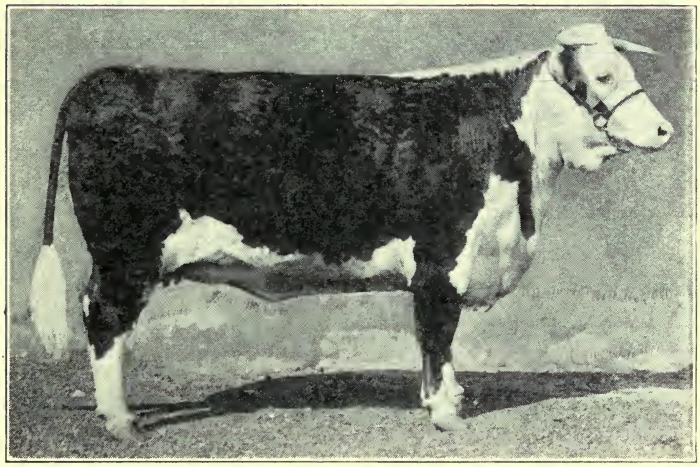

Figure 116.—A prize winning Hereford cow.

the underline and sometimes on the back. In size the Herefords are large, ranking close to the Shorthorns. This breed conforms to the ideal beef type very closely, as they are low-set, smooth, and fine in bone. The body of the Hereford is cylindrical, with a round, plump appearance.

As range cattle Herefords rank very high; for they are good grazers, doing well on rough range, and readily withstanding hardship. As milkers they do not rank high; yet they usually feed their calves well. They are widely distributed and are proving expecially useful in the range section of the United States, where they are probably the most popular breed.

Aberdeen-Angus. The Aberdeen-Angus breed of cattle, known as Polled Angus, or "doddies," was developed in north Scotland, from the native cattle of the district.

They are a black, hornless breed that conforms very closely to the ideal beef type. They are very cylindrical

Figure 117.—Black Bird, a champion Aberdeen-Angus Cow

in body with a smooth appearance. On account of fine bone and hair and a neat appearance throughout, the Aberdeen-Angus cattle rank high in quality. In size the breed ranks well, though they are not quite so large as Shorthorns. These cattle are fair grazers, but do better in corn-belt pastures than on the range.

As milkers they do not rank high, but seem to give enough for their calves. In the production of high-class beef, however, the Aberdeen takes first rank; for they have won more prizes than any other breed, both for beef steers and for carcasses.

Galloway. A Scotch breed of cattle known as the Galloway was developed in the hill country of southwestern

Scotland. These cattle are black and hornless like the Aberdeen-Angus, but differ considerably in some other characteristics. The Galloway cattle are squarer in outline than the Angus and they have a longer, thicker coat of hair which is more like fur. They produce high-class beef and do well in extremely cold climates. In the West, where Shorthorns and Herefords are the common types, they are little used.

DUAL-PURPOSE TYPE OF CATTLE

Dual-purpose, or general-purpose, cattle are those supposed to be good for both beef and milk. Some breeders claim that animals of this type can be profitably produced, but as a rule the special dairy or beef cattle are regarded as more desirable.

Red Polled. The Red Polled breed originated in England and has met with some favor in this country. This breed, usually solid red in color, is somewhat smaller than the strictly beef breeds, and more beefy in appearance than the dairy breeds. It is doubtful whether they will ever be popular on the ranges. Very few are found in the West.

Devon. The Devon cattle, a red, horned breed, originated in southwestern England. These cattle are large and smooth, with fine bone. Being rather slow feeders, they have met with but little popularity in the United States.

QUESTIONS

1. What is the probable origin of cattle?
2. Describe a typical beef animal, that is, the beef type.
3. Name the kinds of beefsteak. Which are best? Why?
4. Name the breeds of beef cattle.
5. Briefly describe each.
6. What are dual-purpose cattle?

EXERCISES AND PROJECTS

1. If possible, examine a beef to see the kinds of meat. It might be possible to visit a butcher shop.

2. Collect pictures of the breeds of beef cattle.
3. Visit some farm nearby on which are kept pure-bred beef cattle. Learn the name of the breed. Observe the general color and the location and color of spots. Note the shape and size of body, the shape of head and horns, and the fineness of skin and hair.
4. If time permits practice scoring by a score card.
5. Collect prices on live and dressed beef.

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CHAPTER XXXVII

DAIRY CATTLE

THE DAIRY TYPE

There is a rather close relation existing between the form of an animal and its use. This fact has already been seen in case of beef cattle, which are blocky in form and thickly covered with flesh, their function being to produce the most meat possible. Experiments have shown that cows of this type do not produce as much milk and butter-fat on the average as cows of another type. It has been shown that they require more feed for the production of a given amount of milk or butter-fat, and that they dry off earlier than cows of the other type. Since the function of dairy cattle is to produce milk and butter-fat, very little of their feed is stored in their bodies as flesh. In performing this function certain parts of the body have been worked more than other parts. Therefore, in accordance with the law of nature, that great exercise causes great development, we find the parts of the cow used most in making milk are more highly developed than the parts of her body that are less exercised.

The Udder. Of course, the udder, being the immediate factory where the milk is made, is the point of chief consideration. It must be large, well-shaped, and of fine quality, not meaty.

Milk Veins. It is essential to a good dairy cow, that she have a strong, well developed blood circulation; for this is the agency which distributes the prepared raw materials (the digested food) to the various parts of the body where they are most needed. Especially important is the blood supply to the udder. This quantity can be judged in a gen-

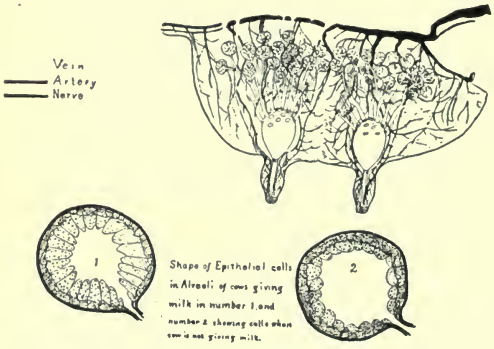

Figure 118.—Showing structure and epithelial cells of the udder.

eral way by the amount of blood leaving the udder in the so-called milk veins extending forward along either side of the abdomen in front of the udder, and entering the abdominal wall through openings called milk wells. It is, therefore, important that these veins be as large and branching as possible, showing a capacity to carry large amounts of blood. The size of the milk vein can easily be determined by inserting the end of the finger in the milk well and noting its size.

Barrel. No matter how large and perfect any factory is, it cannot turn out manufactured goods without raw materials in abundance. Milk is made from the food the cow eats. In order, therefore, to have plenty of raw material on hand from which to produce milk, large amounts of feed must be eaten and be well digested. The conclusion, then, is inevitable: the digestive organs of a cow must be large and vigorous. This, of course, means that a good dairy cow will have a large barrel, or middle.

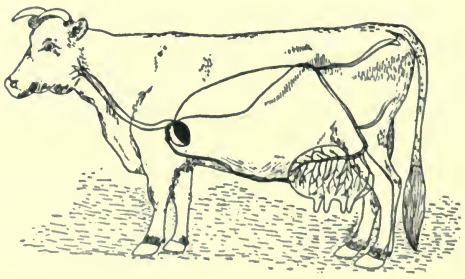

Figure 119.—Diagram showing blood supply to the udder of a dairy cow.

Chest. However great the capacity of any factory or however large the amount of raw material supplied, noteworthy stores of the finished products cannot be produced if the machinery is weak, frail, and short-lived. Just so with the dairy cow. She must be healthy, vigorous, and have a strong constitution if she proves capable of standing up under the severe strain of producing large quantities of milk, and giving birth to healthy vigorous calves. These points, vigor and strong constitution, are indicated by great chest capacity as shown by a deep chest and large heart girth, allowing ample room for large, vigorous vital organs (heart and lungs); and by a large, bright, full eye, large nostrils, and a broad, strong muzzle.

Temperament. The so-called dairy type has been produced as explained above and is built around the points there mentioned. First, the dairy cow should have an active, highly organized temperament with strong nerve force. This is shown by her being lean, spare, and angular and carrying no surplus flesh. A large, bright, active eye goes with a good dairy temperament. Viewed from the side, she should be deeper through the hind part of her body than in front, showing an inclination to a wedge shape. From the rear and above, another wedge is seen, broad across the hooks, or hip bones, and narrowing down to a point at the withers.

Conformation. A more detailed examination of the dairy cow should reveal a lean, shapely head with broad, strong muzzle and jaw, a full, bright, active eye, ears medium sized and of fine texture, and horns, when present, that show refinement and quality throughout. The neck is thin and usually somewhat long. The shoulders are prominent and lacking in covering and come together in sharp withers at the top. The back should be straight, the spinal processes prominent, with little covering and having an openness between them that is entirely absent in the beef type. The body should be long and deep. The ribs are far apart though

not so wide sprung as in beef cattle. They should be long, giving great capacity to the digestive and vital organs. The space should be long from the attachment of the last rib to the hip bone and from the hip bone to the pin bone. Lean-

Figure 120.—A typical head of a Jersey bull.

ness and prominence of bones should characterize the rump. The hind quarters should be thin and spare, leaving ample room between the legs for a large udder.

The udder should be large, and attached high behind and far forward. The four quarters should be equally developed

and not too distinctly divided by grooves. The udder should be free from meatiness and when milked out should collapse and be very loose and pliable, showing that the size is due entirely to the active milk-producing cells. The milk veins leaving the udder in front should be large and tortuous, extend far forward on the body, and enter the abdomen

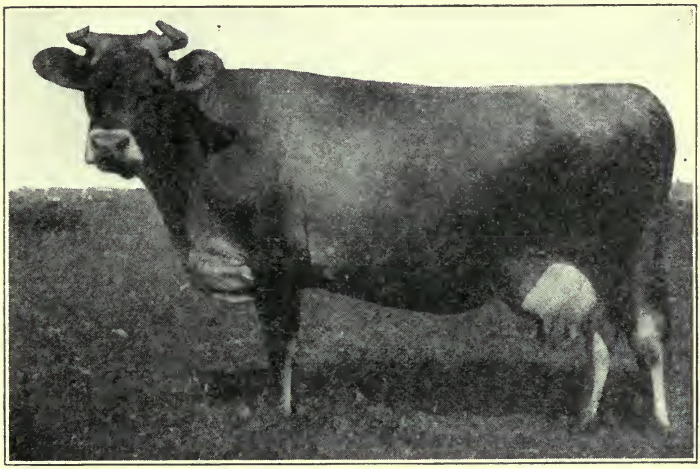

Figure 121.—A pure-bred Jersey cow—a prize winner.

through large milk wells, thus showing a large blood supply to the udder. If a cow has more than one milk well on a side, so much the better.

Quality, desired in the dairy cow as in all other classes of animals, is shown in about the same way; namely, thin pliable skin, fine, silky hair; and fine, dense bone and horn. These characteristics are important.

Dairy Bulls. In dairy bulls the same general dairy type is demanded as in dairy cows except that the bull must show pronounced masculinity by having a burly head and a well-developed crest on the neck. Dairy bulls usually carry more flesh and show less of the wedge shape than the cows of

the same breed. Aside from this difference the desirable points are very similar.

As mentioned above, no matter which of the four dairy breeds is being considered, the dairy type just described should be found in all its points.

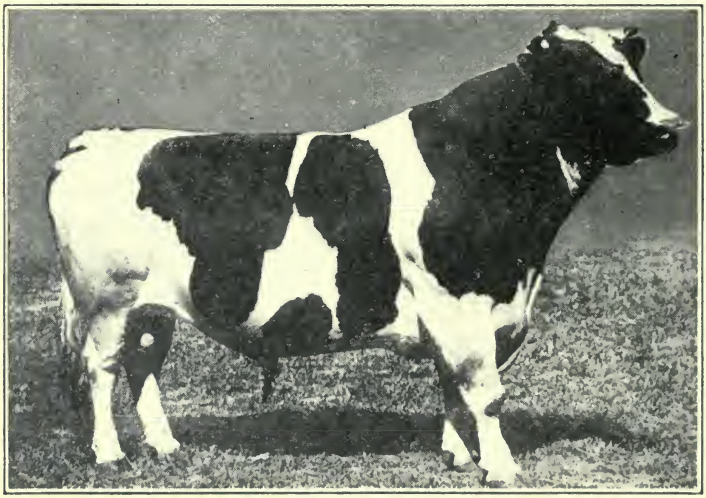

Figure 122.—Holstein-Friesian bull.

DAIRY BREEDS

The Jersey originated on the Island of Jersey which has a land area of about 40,000 acres in the English Channel; they developed, supposedly, from native stock of the island, mixed with cattle from the neighboring districts of France. They have been kept pure by laws prohibiting all foreign cattle from landing on the island except for immediate slaughter. Not until 1850 were Jerseys imported to this country, but since then large numbers have been brought over. They are perhaps the smallest of the dairy cattle, the cows weighing from seven hundred to eleven hundred pounds, and mature bulls about thirteen hundred pounds. In color they

are fawn, though this varies from a very light to an almost black color. White occurs, though not popular; yet some of the greatest animals of the breed have had white markings. The most striking features of the Jerseys are beauty, color, short dish-faces, prominent, beautiful eyes, and deer-like

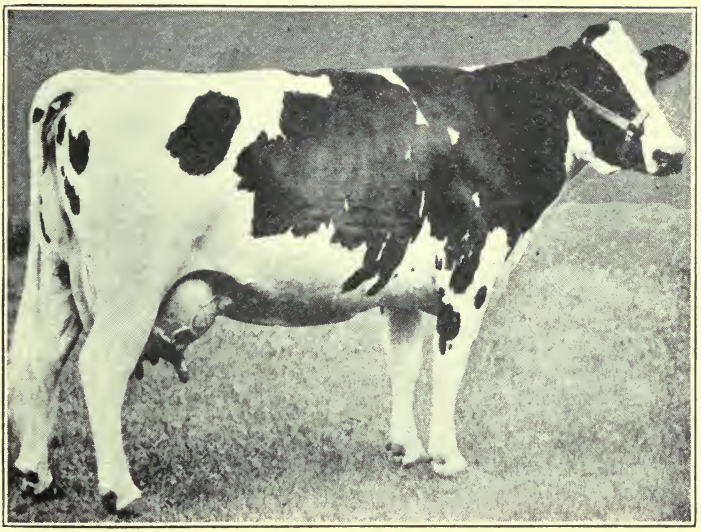

Figure 123.—A champion butter-fat cow of the world. She produced in one year 27,762 lbs. of milk and 1,205.1 lbs. of butter-fat.

calves. They have always been noted for their rich milk, containing as it does from four and one half to six per cent fat. Their milk yield is not so large as some of the other breeds, though its richness brings the total fat production up to a high figure. One Jersey cow, Sophia 19th, of Hood Farm, produced in one year 999.14 pounds of fat and and 17,557.75 pounds of milk.

The Holstein-Friesian cattle were developed in Holland. This type has been known upwards of two thousand years. Of course the breed has been considerably improved in that

time, but the foundation stock seems to have been the native cattle of that country.

Much of the best land in Holland is below the level of the sea, the water being held back by immense dikes. Grasses grow rather luxuriantly, though they are of the coarser, less

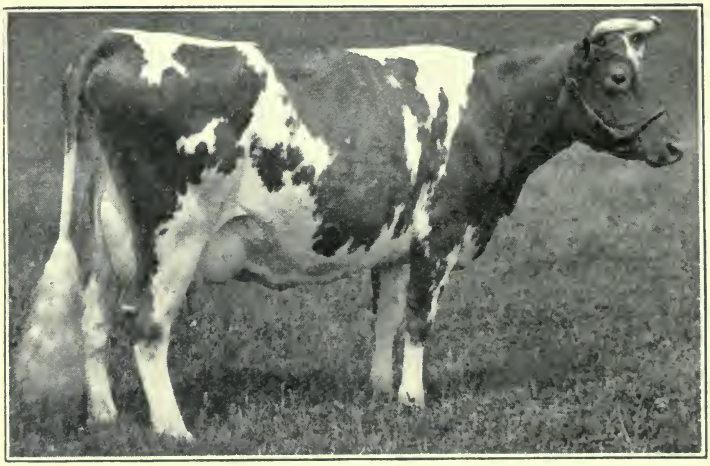

Figure 124.—Langwater Dairy Maid. Sold for $6,150. When eight years old she produced 16,949.2 lbs. of milk and 812.66 lbs. of butter-fat.

nutritious varieties. Thus the animals developed there have adapted themselves to these conditions and are able to utilize considerable quantities of the coarser feeds.

No doubt the early Dutch settlers of New York and vicinity brought over their own breed of cattle. We have record of a definite importation in 1795; but not until 1861 and after were large importations made and the animals kept pure.

These cattle are the largest of the five dairy breeds, the cows weighing from twelve hundred to fifteen hundred pounds and bulls from nineteen hundred to twenty-five hundred pounds. In color they are black-and-white spotted, the

proportion varying from almost pure white to almost pure black. Their heads are inclined to be long, narrow and plain, and the horns often appear small. The body is large and roomy with the udder often very large. There is consider-

Figure 125.—A noted Ayrshire bull showing type, quality and smoothness found so highly developed in this breed.

able difference in the type of Holstein cows, some carrying decidedly more flesh than others which adhere more strictly to the dairy type. They all lack the refinement, quality, and beauty characteristic of the Jersey.

Holstein cows give more milk than any other breed, though the per cent of fat in it is lower. About three per cent is common and four per cent is unusual. One cow, Dutchess Skylark Ormsby, gave in one year 27,761.7 pounds of milk and 1,205.09 pounds of fat, this being the present (1917) world record for butter-fat.

Guernsey Cattle originated on the island of that name, near the Island of Jersey. The ancestry and conditions of

development of the Guernseys are very similar to those of the Jersey cattle, though somewhat more care seems to have been taken in the early breeding of the Jersey.

The first importation of Guernsey cattle to the United States occurred about 1850. These were brought directly from the Isle of Guernsey in the English Channel.

Figure 126. — Lilly of Willow-Moor, a noted Ayrshire cow having a record of 22,106 lbs. of milk containing 888.7 lbs. of butter-fat and showing good type and smoothness.

Guernsey cattle are somewhat larger and more uniform than Jerseys; the cows weigh about one thousand pounds, and bulls about fifteen hundred pounds. Their color ranges from a light to a dark fawn, with or without white markings. In amount of milk and butter-fat and in per cent of fat the production of the Guernsey cow is very similar to that of the Jersey. Murne Cowan, the champion cow of the Guernsey breed, produced 24,008.0 pounds of milk and 1,098.18 pounds of fat.

Ayrshire cattle are a Scotch breed originating in the county of Ayr in southwest Scotland, the region made famous by Robert Burns. Most of the land, except near the sea, is rather hilly and rough, though it produces an abundance of good grazing in the summer. Back from the sea the winters are rather severe.

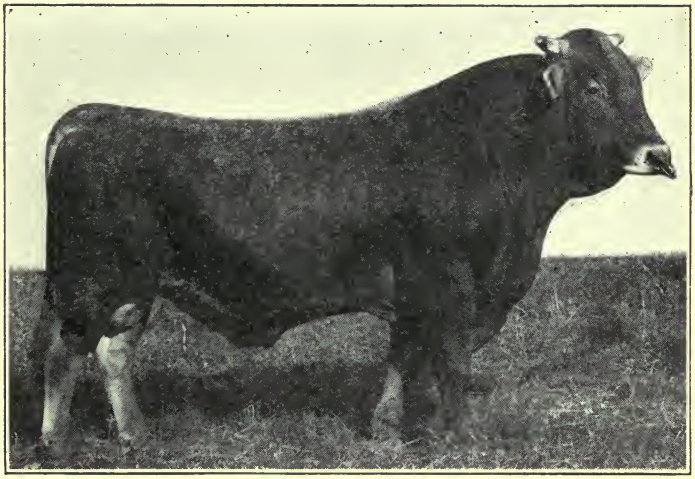

Figure 127.—A noted Brown Swiss bull, Reuben 2927, showing type and ruggedness desired.

This breed is regarded by all authorities to have been founded later than the three preceding dairy breeds. Its origin is not definitely known, though the breed is thought to be the result of a mixture of the native cattle of the district, with Shorthorns and with Jersey, Guernsey and Alderney cattle.

Ayrshires are not numerous in the United States, though some good herds are kept. There seems to be no definite record of their introduction to this country before 1837.

In size this breed is about the same as the Guernseys. They are rounder and plumper and carry more meat than

any other dairy breed. The color may be red and white, or brown and white, either color predominating. The head of the Ayrshire is very characteristic, carrying as it does rather long, out-and-upturned horns. The udders are perhaps more nearly perfect than the udders of any other breed, being

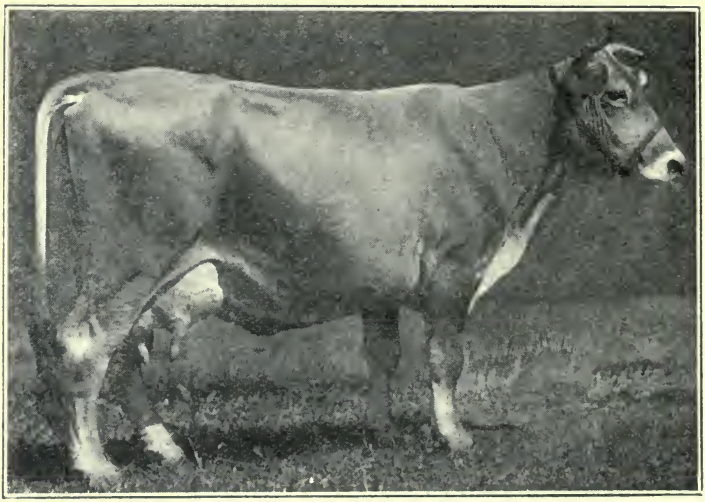

Figure 128.—Lottie, a pure-bred Brown Swiss cow, who gave 17,593 lbs. of milk and 664.2 lbs. of fat in official record.

exceptionally well-balanced and carried close up to the body though the teats are often small.

The milk and butter records of the Ayrshire are only fair. The milk usually tests three and two tenths to four per cent.

Brown Swiss cattle are native to the cantons of Zurich, St. Galen, Luzern, and Schwyz in northeast Switzerland. This breed is one of the oldest in existence. It is supposed to have descended from cattle found in this region since before the beginning of human history. This belief rests on the discovery in ruins of the Swiss Lake Dwellers of skeletons of animals closely resembling the characteristics of the present

Brown Swiss. Very little infusion of foreign blood is thought to have taken place in their development.

The Brown Swiss is one of the larger dairy breeds. The cows weigh from twelve to fourteen hundred pounds and the bulls frequently pass the ton mark. In color they vary from a silver gray to a deep, rich, brownish-black. A lighter strip down their backs and a yellowish muzzle are their two chief marks. The quiet, nonresentful disposition of this breed is very noticeable and recommends them to many who

STUDENTS' SCORE CARD

DAIRY COW

SCALE OF POINTS FOR DAIRY COW	Score
DAIRY TEMPERAMENT AND MILK SECRETING SYSTEM—fifty points	
1. **Udder,** large but not pendulous; attached high behind and extending far forward; pliable and free from meatiness; evenly quartered; not deeply indented between teats; udder veins numerous and plainly visible	30
2. **Veins and Wells,** milk veins large, long, active, tortuous, branching and entering numerous large wells	7
3. **Teats,** evenly and symmetrically placed on quarters; convenient and uniform in size and length; free from lumps, warts and tendency to leak	3
4. **Body,** angular; wedge shape; lean and clear cut throughout	4
5. **Disposition,** active, with good nerve control, not flighty	4
6. **Eye,** prominent but not popping; bright and quiet	2
FEEDING CAPACITY—twenty points	
7. **Barrel**	
Deep—ribs long, abdomen large but firmly held up by strong muscular development	6
Wide—ribs well sprung; loin broad and strong	6
Long—ribs far apart and broad, spinal processes prominent, loin long	6
8. **Muzzle,** broad, lips full	1
9. **Jaws,** deep and strong	1
CONSTITUTIONAL STRENGTH AND VIGOR—twenty points	
10. **Chest,** deep, wide on floor and full at elbows, indicating lung capacity	12
11. **Carriage,** alert and energetic	4
12. **Skin,** thin, loose and mellow, indicating good circulation and secretion; hair fine	3
13. **Nostrils,** large and expanded	1
GENERAL APPEARANCE, showing large size, symmetry and balance of parts into a completed whole—ten points	
14. **Head,** lean, broad between eyes, features clean cut and intelligent	2
15. **Neck,** thin, lean, trim, rather long, joined neatly to head and shoulders	1
16. **Withers,** thin and not open	2
17. **Top-line,** straight and strong, carrying level over tail head	3
18. **Breed Character,** pure-breds to show size, markings and general characteristics required; grades to show the predominence of the blood of some dairy breed	2
TOTAL	100

dislike the active, nervous temperaments of most of the other dairy breeds.

Records give the date of their first importation to the United States as 1869. Since that date the numbers have increased by importation and breeding till there are now more than 11,000 registered in the herd books of the American Brown Swiss Cattle Breeders' Association.

Until 1908 they were classed as dual-purpose cattle, but since that date the association has been emphasizing their dairy qualities and they are now recognized as a distinctly dairy breed. The Registry of Production for the breed was established in 1911. Butter-fat records for cows of this breed are not especially high. Seven-day records above 14 pounds of fat and yearly records exceeding 700 pounds are rare. The milk usually tests between three and one half and four per cent.

QUESTIONS

1. Illustrate the relation existing between the form of an animal and its use.
2. What has been the underlying cause of the development of dairy type?
3. Of what value is constitution in dairy cattle? How is strong constitution shown?
4. What is meant by dairy temperament? How is it shown?
5. Give a brief statement of the origin and early history of Jersey cattle.
6. What are the chief characteristics of the Jersey?
7. Where and under what conditions did Holstein-Friesian cattle develop?
8. What are the distinguishing characteristics of Holstein-Friesian cattle?
9. Give briefly the early history and development of Guernsey cattle?
10. How do Guernseys differ from Jerseys and Holsteins?
11. Discuss the history, development, and distinguishing characteristics of Ayrshire and Brown Swiss cattle.

EXERCISES AND PROJECTS

1. To determine the production of dairy cows, secure scales, milk sheet, test bottles, milk thief, and Babcock testing machine.

   Note: If a milk thief is not available, mix thoroughly and remove a small quantity with a dipper or a spoon.

   Weigh the milk of each cow each milking for one month. Record the weight each time on the milk sheet under the proper cow's name. For some one week during the month take a composite sample of each cow's milk by putting a small sample of each of the fourteen milkings into a properly labeled sample bottle. A pint fruit jar may be used if a regular sample bottle is not available. As soon as the milk is weighed thoroughly stir it, preferably by pouring it from one pail to another, and immediately take the sample. This can be done with a regular milk sampler or with a dipper. In the summer or if the sample bottles are kept where it is warm, a preservative will be necessary to keep the milk sweet. A few drops of formalin or a special corrosive sublimate milk preserving tablet may be used in each bottle. At the end of the week test the various samples for butter-fat (see Chap. XLV.) At the end of each month total each cow's milk and multiply the total weight by the test as found during the test week to get the amount of butter-fat. If this is multiplied by the market value per pound the value of the fat is obtained.

2. To find the cost of feeding a dairy cow, weigh separately all feeds given the cow for two days during each month. Taking these weights as averages determine how much of each feed she has consumed during the month. Multiply the monthly weight of each feed thus obtained by its market price to get the value of the feed eaten.

   Note: Accurate figures on the profit of dairy cows can only be obtained by taking into account, in addition to the cost of feed and the value of the product, the interest and the depreciation on the investment involved, the cost of bull service, the cost of labor, insurance, etc., and the value of the calf and manure produced.

3. Use the results of Exercises 1 and 2. Subtract the cost of the feed consumed by the cow from the value of the butter-fat produced during the same period and this gives the profit above cost of feed.

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CHAPTER XXXVIII

THE HORSE

Man's most useful helper among the domestic animals is probably the horse, and, on account of this help, the beauty and intelligence of the horse have been the theme of song and story almost since the world began.

In prehistoric times horses were small animals about the size of a fox terrier dog, from which they have evolved to their present size. Although the remains of prehistoric horses are found in America, there were probably no horses here when the white man arrived.

History. The first horses celebrated in history to any great extent are the Arabian, a small, beautiful pony type found in the desert of Arabia. These horses were used as foundation stock for a number of breeds and had much to do with the molding of modern breeding. Horses of the Arab type, but coarser, were brought first to America from Spain and served as a foundation stock for our wild horses, Indian ponies and mustangs.

There are many types and breeds of horses used now, varying in size from the tiny Shetland of 150 to 300 pounds to the great Shire or Percheron of 2,000 to 2,400 pounds, and ranging in speed from the swift running Thoroughbred to the slow drafter.

Horses differ very much in weight, style, and speed; yet all can be judged in somewhat the same way.

In general appearance a horse should be symmetrical, that is, about the same from ground to top of withers as from shoulder point to tail. The horse should show life, vigor and style by the way it carries the head, ear, and tail. A slouchy, listless appearance is detrimental.

Conformation. The head of a good horse is of fair size and bony in its appearance, with a straight face, a broad, full forehead, and large, bright eyes that show intelligence. The dished face, narrow forehead, and small, round eye are generally marks of a bad disposition. A good strong jaw is wanted, as it is the mark of a good feeder. The muzzle should be rather fine, but the nostrils large. The ears should be fairly fine, denoting quality, and neatly held, showing style. A lop ear is unsightly and generally indicates a sluggish disposition.

The neck should be long and well-arched, and clean-cut about the throat so as not to impair breathing.

The shoulder should be so sloping that, when viewed from the side, the neck comes out on top of the body and not in front as in the straight-shouldered horse. The withers should be fine and fairly prominent in all breeds.

The body of the horse should have a good big middle, with long, well-arched ribs and a low flank. Good depth and fair width are wanted in order to get the capacity for the vital organs. Slim-bellied horses lack endurance, being generally hard to keep in good condition, while the horse with a good middle and low flank, showing capacity, is generally easily maintained. The back should be straight; the loin, short, broad, and well-muscled. Stallions and geldings should be close-ribbed; that is, the last rib should be close to the point of the hip, making the loin strong. More length and roominess is wanted in mares.

The hind quarter should be heavy and well-muscled; for a horse does most of the propelling with the hind parts. The croup should be long and straight, for this adds balance and gives more room for muscles. The tail should attach fairly high and be carried well out. The width should be carried down into the quarters, making the horse heavy through stifles and breech. The gaskin should be neatly turned, but heavily muscled.

The legs are the most important parts of the horse. "No foot, no horse" or "no leg, no horse" are true statements. The front legs of the horse are straight when a plumb line dropped from the shoulder point passes through the center of the knee, cannon, and foot. When viewed from the side, a plumb line dropped from center of forearm should pass through the knee and cannon and drop back of the foot. A fairly long sloping pastern gives elasticity to the step, increasing wearing ability. The cannon should be wide and clean-cut and the knee deep and strong.

The front feet should be large and round with an open heel and a good straight hoof.

The hind leg, when viewed from the side, should be shaped so that a plumb line dropped from the point of the buttock should strike the back of the hock and drop parallel to the back of the cannon. This gives a strong leg that will withstand wear. If the leg is crooked, curby-hocked, as it is called, the conformation is weak. When viewed from behind, plumb lines dropped from the sides of the tail should bisect the hock, cannon, and foot. The hocks and feet are then the same distance apart. A wide, bony, clean-cut hock that is supported by a wide, strong cannon is desirable.

Action is very important in all horses and should be carefully considered. At the walk the horse should travel fast with a long, straight stride. At the trot the same straight action is wanted, but the horse should travel fast and fairly high. In draft horses the walk is the more important, while in light horses the trot deserves more consideration.

TYPES AND BREEDS OF HORSES

Four types of horses are recognized: (1) the saddle type, (2) the roadster type, (3) the carriage, or coach, type, and (4) the draft type.

The Saddle Type. These vary from the small pony to the hunter in size, but are usually horses of quality, with action and nerve.

The Arabian is a small but wiry pony whose native home is Arabia. In color it is generally bay, chestnut, gray, and white, with now and then a brown or black. Spotted, or pinto, horses are seldom if ever found among true Arabians.

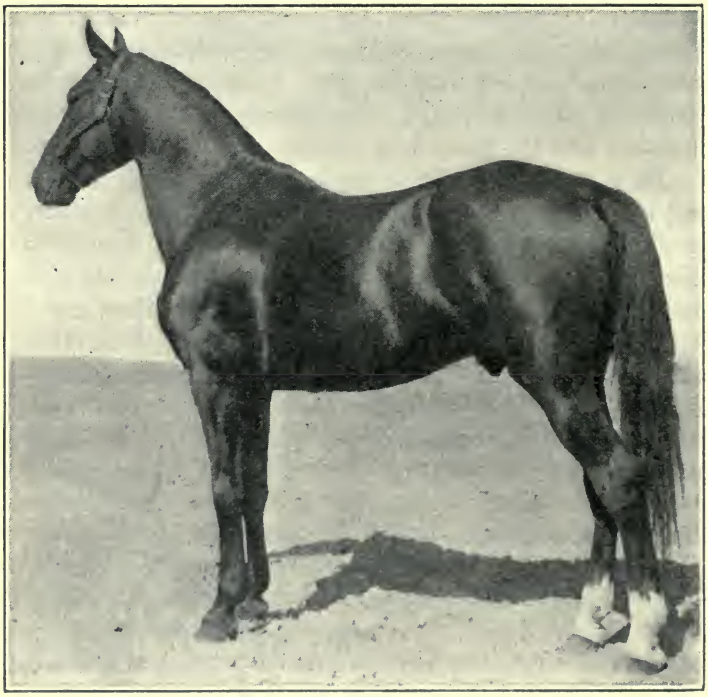

Figure 129—Standard Bred trotter.

Their influence on modern breeds is very marked, much of the speed and quality of our horses being due to this blood.

The Thoroughbred is an English breed developed from the Arab and is the fastest horse. Thoroughbreds are most commonly bay and chestnut, and range in weight from 800 to 1,150 pounds. On a straightway track Salvator ran a

mile in 1.35½, and on a circular track Dick Wells made the mile in 1.37⅖.

The American saddle horse, a superior type of riding horse, developed in the United States from Thoroughbred ancestry, is a horse of considerable quality and finish, and is

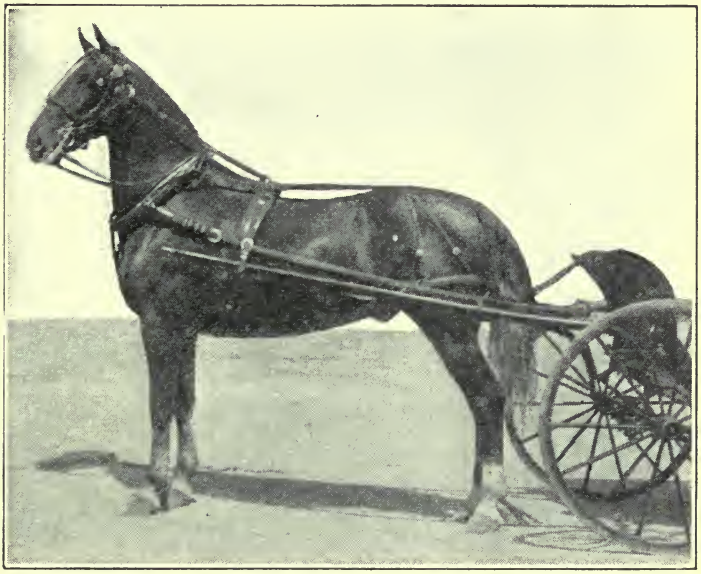

Figure 130.—Coach, or carriage, horse.

variously gaited, having in addition to the regular walk, trot and canter, the rack and either the fox trot or running walk. Saddlers range from 900 to 1,150 pounds; the most common colors are bay, chestnut, and black.

Another type of saddle horse is much used. He varies in type, and has but three gaits: walk, trot and canter.

Mustang or Broncho. The wild horses of western America are of the saddle type. They rank in endurance and stamina with any horse known. The western horse, however,

is not of mongrel blood; for his ancestors came from Spain and are of the hot-blooded races akin to the Arab. The greatest fault with the western pony is the lack of quality and finish and the small size.

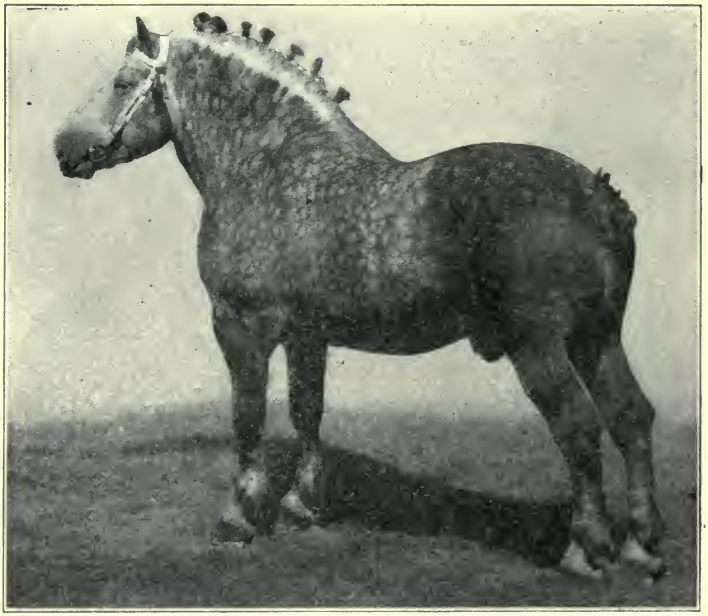

Figure 131.—An undefeated grand champion Percheron stallion.

The Roadster Type. This is the light harness horse used for fast driving and racing.

The American trotter, or pacer, or standard bred, the greatest light harness horse known, was developed in America from Thoroughbred ancestry. This breed was founded by the great horse, Hambletonian, foaled in 1849.

There is no distinct type, but the best of them are very symmetrical and stylish with quality.

The record for a mile at the trot is 1:58 held by Uhlan, and at the pace is 1:55¼ held by Dan Patch.

The Orloff trotter is a Russian breed that is larger than the American Type and not so fast.

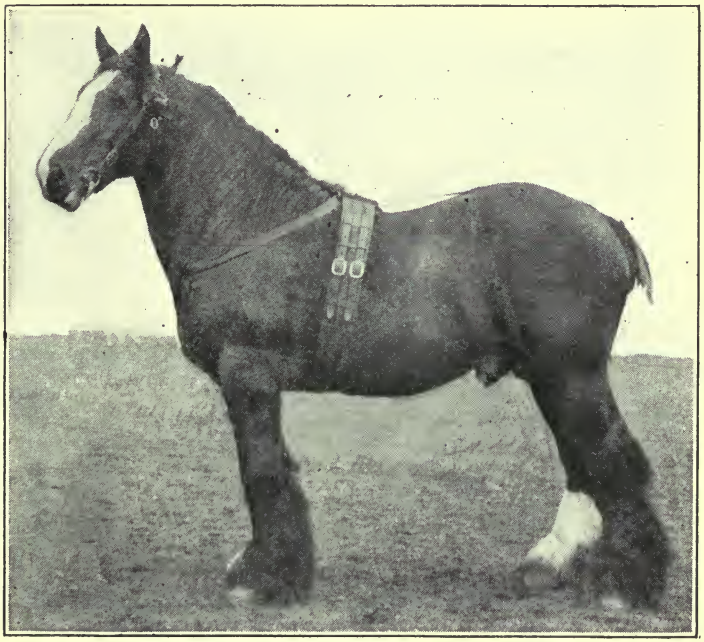

Figure 132.—A champion Shire stallion.

The Coach, or Carriage, Type. This is the heavy-harness type used more with heavy carriages. Though showy when in action, they are not speedy. Because automobiles have replaced these horses, there is but a limited market for them.

The Hackney is an English coach breed of remarkable smoothness and very high action. Hackneys vary in size from 1,150 to 1,250 pounds. The common colors are chestnuts, bays, and browns.

French Coach, German Coach, and Cleveland Bay, are all breeds of this type, but are of no great importance in America.

The Draft Type. This is seen in the big, slow-moving work horse. Drafters should weigh at least 1,600 to 2,400 pounds. Size and weight are the prime requisites with these horses and to get it some quality and finish may be sacrificed.

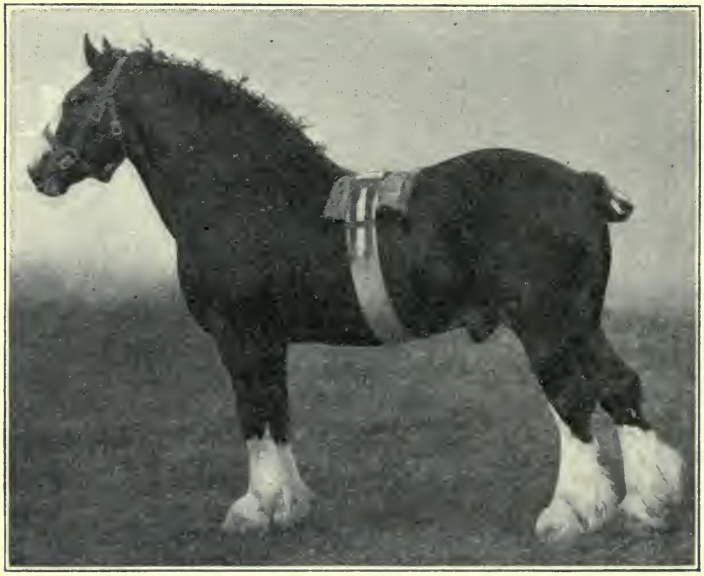

Figure 133.—A champion Clydesdale stallion.

The Percheron, the most generally used draft horse in the United States, originated in France. In weight, Percherons range from 1,400 to 2,200 pounds. In colors, gray and black predominate, though chestnut, bay, brown and roan occasionally occur. They are remarkably smooth, and show quality and good action for drafters. Percherons mature early and have amiable dispositions, which make them generally liked. Crossed on common mares they give excellent results, which fact accounts for their popularity.

Shire horses, formerly called the English cart horse, originated in the south of England. This is one of the oldest and largest breeds, weighing up to 2,400 pounds. Bays, browns, and blacks are the predominating colors, though chestnut is common, and gray and roan appear now and

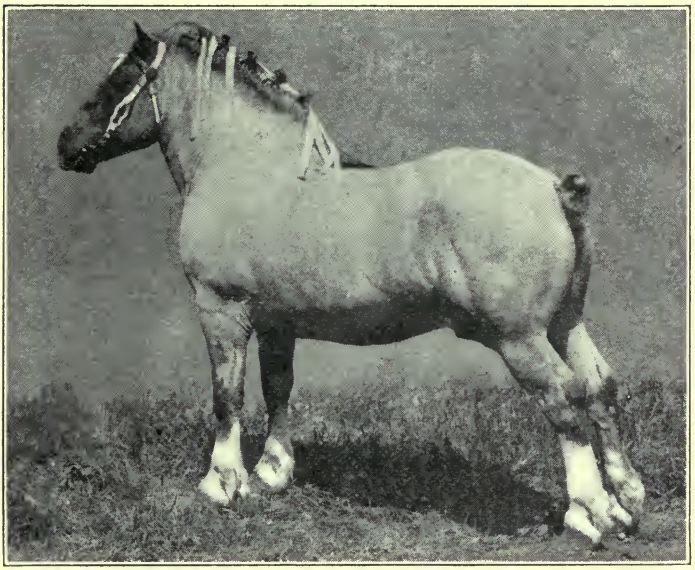

Figure 134. — Farceur, an undefeated grand champion and probably the most outstanding specimen of the Belgian breed in America.

then. Shire horses are heavy boned and rather rough in their make-up, and do not mature as early as some of the other draft breeds. A Shire characteristic is the long hair or feather which is found from fetlock to knee and from fetlock to hock.

Clydesdale horses originated in Scotland. They are, in color, the same as Shires, but they are a smaller breed, weighing 1,600 to 2,200 pounds and having less of the feather on the legs, but have more slope to pasterns and better feet

than almost any other draft breed. Clydesdales are very snappy actors, have wonderful feet and legs and are considered good wearing horses when used on rough roads.

The Belgian horse, originated in Belgium, is one of the largest of the draft breeds, individuals weighing up to 2,400

Figure 135.—A Suffolk Punch stallion.

pounds. In color they are bay, chestnut, brown, or roan for the most part, though gray and black do appear. These horses are smoothly made like the Percheron, but do not have quite the quality. Belgians are becoming rather popular in the United States.

The Suffolk Punch is an English breed of draft horse, all of which are chestnut in color. This horse is rather smaller than the other draft breeds, weighing 1,500 to 1,900 pounds. The Suffolk is regarded as a very good farm horse, but as yet very few of them are being raised in this country.

STUDENTS' SCORE CARD
DRAFT HORSES

SCALE OF POINTS—FOR GELDING	Score
1. **Age**	
GENERAL APPEARANCE:	
2. **Height**	
3. **Weight,** over 1500 lbs..... score according to age	4
4. **Form,** broad, massive, proportioned	4
5. **Quality,** bone clean, fine, yet indicating sufficient substance; tendons lean; skin and hair fine	4
6. **Temperament,** energetic, good disposition	4
HEAD AND NECK:	
7. **Head,** lean, medium size	1
8. **Muzzle,** fine, nostrils large, lips thin, even	1
9. **Eyes,** full, bright, clear, large	1
10. **Forehead,** broad, full	1
11. **Ears,** medium size, well carried	1
12. **Neck,** muscled, crest high, throatlatch fine, windpipe large	1
FOREQUARTERS:	
13. **Shoulders,** sloping, smooth snug, extending into back	2
14. **Arm,** short, thrown forward	1
15. **Forearm,** heavily muscled, long, wide	2
16. **Knees,** wide, clean cut, straight, deep, strongly supported	2
17. **Cannons,** short, lean; sinews large, set back	2
18. **Fetlocks,** wide, straight, strong	1
19. **Pasterns,** sloping, lengthy, strong	3
20. **Feet,** large, even size, straight; horn dense, dark color; sole concave; bars strong; frog large, elastic; heel wide, high, one half length of toe	8
21. **Legs,** viewed in front, a perpendicular line from the point of the shoulder should fall upon the center of the knee, cannon, pastern and foot. From the side, a perpendicular line dropping from the center of the elbow joint should fall upon the center of the knee and pastern joints and back of hoof	4
BODY:	
22. **Chest,** deep, wide, low, large girth	2
23. **Ribs,** long, close, sprung	2
24. **Back,** straight, short, broad	2
25. **Loin,** wide, short, thick; straight	2
26. **Underline,** flank low	1
HINDQUARTERS:	
27. **Hips,** smooth, wide	2
28. **Croup,** long, wide, muscular	2
29. **Tail,** attached high, well carried	1
30. **Thighs,** muscular	2
31. **Quarters,** deep, heavily muscled	2
32. **Gaskins or Lower Thighs,** wide, muscled	2
33. **Hocks,** clean cut, wide, straight	8
34. **Cannons,** short, wide, sinews large, set back	2
35. **Fetlocks,** wide, straight, strong	1
36. **Pasterns,** sloping, strong, lengthy	2
37. **Feet,** large, even size, straight; horn dense, dark color; sole concave; bars strong; frog large, elastic; heel wide, high, one half length of toe	6
38. **Legs,** viewed from behind a perpendicular line from the point of the buttock should fall upon the center of the hock, cannon, pastern and foot. From the side, a perpendicular line from the hip joint should fall upon the center of the foot and divide the gaskin in the middle; and a perpendicular line from the point of the buttock should run parallel with the line of the cannon ...	4
ACTION:	
39. **Walk,** smooth, quick, long balanced	6
40. **Trot,** rapid, straight, regular	4
TOTAL	100

STUDENTS' SCORE CARD
LIGHT HORSES

SCALE OF POINTS—FOR GELDING	Score
1. **Age**	
GENERAL APPEARANCE:	
2. **Weight**	
3. **Height**	
4. **Form**, symmetrical, smooth, stylish	4
5. **Quality**, bone clean, fine, yet indicating sufficient substance; tendons defined; skin and hair fine	4
6. **Temperament**, active, good position	4
HEAD AND NECK:	
7. **Head**, lean, straight	1
8. **Muzzle**, fine, nostrils large, lips thin, even	1
9. **Eyes**, full, bright, clear, large	1
10. **Forehead**, broad, full	1
11. **Ears**, medium size, pointed, well carried not far apart	1
12. **Neck**, muscled, crest high, throatlatch fine, windpipe large	1
FOREQUARTERS:	
13. **Shoulders**, long, smooth, with muscle, oblique, extending into back and muscled at withers	3
14. **Arm**, short, thrown forward	1
15. **Forearm**, muscled, long, wide	2
16. **Knees**, clean, wide, straight, deep, strongly supported	2
17. **Cannons**, short, wide; sinews large, set back	2
18. **Fetlocks**, wide, straight	1
19. **Pasterns**, strong, angle with ground 45°	3
20. **Feet**, medium, even size, straight; horn dense, frog large, elastic; bars strong; sole concave; heel wide, high	6
21. **Legs**, viewed in front, a perpendicular line from the point of the shoulder should fall upon the center of the knee, cannon pastern and foot. From the side, a perpendicular line dropping from the center of the elbow joint should fall upon the center of the knee and pastern joints and back of hoof	4
BODY:	
22. **Chest**, deep, wide, low, large girth	2
23. **Ribs**, long, close, sprung	2
24. **Back**, straight, short, broad, muscled	2
25. **Loin**, wide, short, thick	2
26. **Underline**, long; flank let down	1
HINDQUARTERS:	
27. **Hips**, smooth, wide, level	2
28. **Croup**, long, wide, muscular	2
29. **Tail**, attached high, well carried	1
30. **Thighs**, long, muscular, spread, open angled	2
31. **Quarters**, heavily muscled, deep	2
32. **Gaskins or Lower Thighs**, long, wide, muscled	2
33. **Hocks**, clearly defined, wide, straight	5
34. **Cannons**, short, wide, sinews large, set back	2
35. **Fetlocks**, wide, strong	1
36. **Pasterns**, sloping, strong	2
37. **Feet**, medium, even size, straight; horn dense, frog large, elastic; bars strong; sole concave; heel wide, high	4
38. **Legs**, viewed from behind a perpendicular line from the point of the buttock should fall upon the center of the hock, cannon, pastern and foot. From the side, a perpendicular line from the hip joint should fall upon the center of the foot and divide the gaskin in the middle; and a perpendicular line from the point of the buttock should run parallel with the line of the cannon	4
ACTION:	
39. **Walk**, elastic, quick, balanced	5
40. **Trot**, rapid, straight, regular, high	15
TOTAL	100

QUESTIONS

1. Describe ancient horses.
2. Give the history of our horses.
3. Describe the parts of a good horse.
4. Name and differentiate the types of horses.
5. Name and describe the breeds of horses.
6. Why do the legs and feet of a horse deserve so much attention?
7. What is quality in a horse?
8. How valuable is weight on a draft horse?

EXERCISES AND PROJECTS

1. Collect pictures of the breeds of horses.
2. Collect prices on various kinds of horses.
3. Visit one or more farms on which are kept some pure bred horses. Observe color, general shape, size and shape of feet and legs, the fineness and length of hair, color and length of mane and tail, and the friendliness suggested in the head and eye.
4. If convenient, try scoring according to score card.

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CHAPTER XXXIX

THE HOG

The hog is the most lowly of farm animals, but gains favor from the fact that it is one of the most profitable, being called the "mortgage lifter of the farm."

Figure 136.—A good type Berkshire.

THE LARD TYPE

The lard-type hog is a low-set, blocky pig with considerable width of back and depth of rib. These are the common hogs of the corn belt and form about nine tenths of all hogs sent to the big markets. This type of pig should have a rather short fine head, with good width between the eyes, fine ears, and a light jowl. The neck should be short and full; the shoulders, though wide and deep, should be long and well-arched and of an even width, carried out well to the tail. Good width and depth of chest is liked, as it shows constitution, and the sides should be deep and long.

The ham should be heavily fleshed, deep and plump, extending down to the hock. The feet and legs in lard-type pigs are important, especially those retained for breeding purposes. Plenty of bone, straight pasterns, and good feet are desirable to bear up weight. Straight fine hair is liked on hogs, as it is an indication of quality.

Breeds. *The Berkshire,* an English breed, is one of the oldest breeds and is most generally raised in the United

Figure 137.—A Poland China sow.

States. Berkshires are black with usually six white points: face, feet, and tip of tail. The distinguishing characteristics of the Berkshires are the upright ears and a dished face, with a short, sometimes upturned, nose.

As boars weigh up to 700 pounds and sows up to 500 pounds, the Berkshires are a rather large breed. Being prolific and good mothers, they are regarded as very good breeders. As killers the Berkshires rank high, for they produce a superior meat, there being considerable lean in proportion to fat.

Poland China hogs originated in the United States and are a typical lard-type breed. Polands are black with six white points but have a rather short body, a straight face,

and drooping ears. Poland Chinas rank medium to large, boars weighing on an average of about 600 pounds and sows about 500 pounds. The Poland breed has been criticised because there is a tendency for them to be poor breeders. To avoid this sows should be selected that have long bodies and are open between hips and ribs.

The Duroc Jersey is a red American breed that is in general of the same type as the Poland China. Duroc Jer-

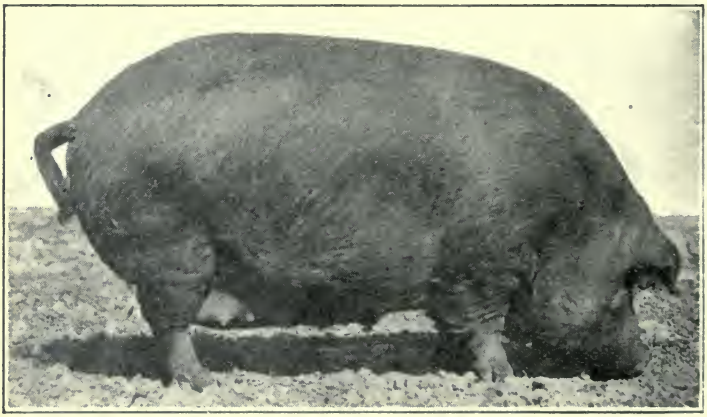

Figure 138.—A Duroc Jersey sow.

seys are cherry red in color, have a straight face and drooping ears. In size the Duroc is large, boars weighing up to 600 pounds and sows up to 450 pounds. They are very prolific and are good mothers, this being an important point in their favor.

Chester White pigs originated in the United States and are quite popular in the Middle West. This breed of white hogs is typical of the lard-type, have a straight or slightly dished face and drooping ears. In size the Chester Whites are large, boars weighing up to 650 pounds and sows to 450 pounds. Chesters are very prolific and usually raise big

litters. There is an objection to white hogs in the hot, dry climate of the West, as they are likely to sun scald and blister. Where plenty of shade is provided white hogs do well and grow rapidly.

THE BACON TYPE

The bacon-type hogs are in general longer-bodied, narrower, and stand up higher on their legs than the lard type.

Figure 139.—A Chester White sow.

In the bacon type the head is rather long, the jowl light, the neck medium in length, and the shoulders rather neat. The back is narrow but of uniform width and should be strongly arched and carried out well to tail-head. The sides, the region from which the bacon is cut, should be long and deep, and the ham, long though not so plump as in the lard type.

Breeds. *The Large Yorkshire* is a white English breed of bacon hogs that is very popular in Canada, but is found in only limited numbers in the United States. Yorkshire swine are very large, weighing up to 700 pounds and are good breeders. The Yorkshire and Chester White breeds

are not hard to distinguish, because the Yorkshire has an upright ear and a dished face.

The Tamworth is a red English breed that has found some favor in the West, especially in Utah. This is a large breed, boars often weighing 700 pounds and sows 500 pounds. Tamworth hogs are prolific and are good mothers, but are

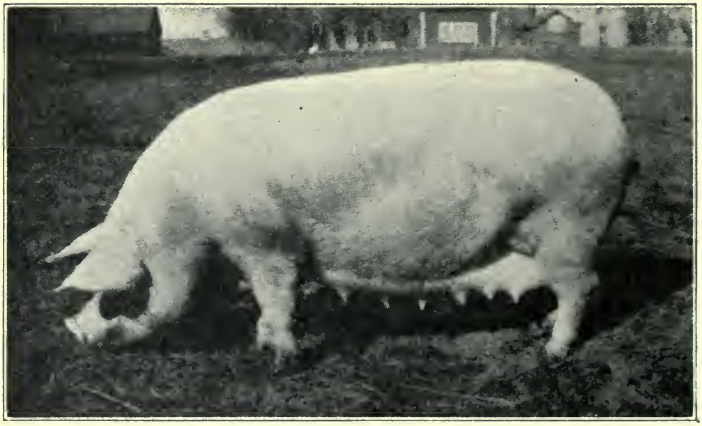

Figure 140.—A Yorkshire sow.

a little slow in maturing. This breed has a very long, straight snout and upright ears.

The Hampshire breed, formerly called the Thin Rined, is another English bacon breed as yet little known in the West. Hampshires are a black and white breed, the white being in the form of a belt extending around the shoulders and front legs. Hampshires are now one of the most important breeds in the corn belt. The breed has lost some of its bacon type and is regarded by many as a lard type.

QUESTIONS

1. Name and describe the types of hogs.
2. Name and describe the breeds belonging to the lard type.
3. Name and describe the breeds belonging to the bacon type.

EXERCISES AND PROJECTS

1. Collect pictures of breeds of swine.
2. Collect prices for live hogs, dressed hogs, and ham, lard, and bacon.
3. Examine one or more breeds of hogs. Note color, shape, size, and any peculiarities of breed.
4. Practice scoring by score card.

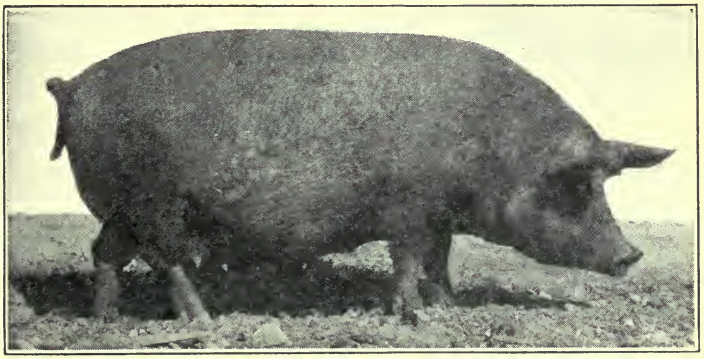

Figure 141.—A Tamworth sow.

STUDENTS' SCORE CARD

FAT HOGS

SCALE OF POINTS FOR FAT HOGS	Score
1. **Weight,** score according to age	4
2. **Form,** deep, broad, low, compact, symmetrical; standing squarely on legs	10
3. **Finish,** smooth, deep, even, mellow covering throughout; free from wrinkles, creases and lumps	10
4. **Quality,** hair fine; bone fine; smooth and refined in general appearance	8
5. **Head,** face short and broad; snout of medium length and not coarse; eyes full and bright; ears fine and of medium size	3
6. **Neck,** short, thick and full; jowl broad, full and firm	3
7. **Shoulders,** broad deep, full, smooth and compact on top	6
8. **Back,** broad, smooth, slightly arched and thickly covered	10
9. **Loin,** wide, thick and smooth	10
10. **Chest,** deep and broad	2
11. **Sides,** deep, smooth, thick and full; ribs close and well sprung	8
12. **Belly,** straight, smooth and firm	2
13. **Flanks,** full and deep	2
14. **Hips,** wide apart and smooth	2
15. **Rump,** long, wide, level and well covered	6
16. **Hams,** smooth, full, wide, deep and firm	10
17. **Legs,** short, straight, strong, and wide apart; pasterns straight and feet of medium size	4
TOTAL	100

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CHAPTER XL

SHEEP MANAGEMENT

The mountainous area in the western states cuts down the ratio of tillable land to the grazing area, and indicates that the sheep business in these sections will continue largely

Figure 142.—First-prize yearling Shropshires.

under range conditions. The greatest immediate development in the industry, however, seems likely to be the establishment and keeping of small flocks on the farms.

Care and Food. Under favorable conditions and with good management, sheep may prove one of the most profitable animals to keep on the ordinary farm. Their care involves comparatively little labor, especially during the busy summer and fall months. Few buildings and little equipment are necessary to start and the cost of maintaining a flock is smaller than for most classes of live stock. A ewe's fleece is supposed to pay about the cost of her keep during the year, leaving whatever she produces in lambs and her own carcass as profit. Sheep manure is the most valuable farm manure produced except that from poultry.

No other class of farm animals is equal to sheep as weed destroyers. They will eat practically all the numerous weeds that grow on the farm, thus keeping down many waste places that would otherwise prove great nuisances in producing and scattering weed seeds. A Kansas farmer was once asked what he did to keep the weeds down on his farm

Figure 143.—Cotswold ewes on pasture.

and he replied that he sold most of them as mutton for five and six cents a pound. In fact, sheep are such good weed destroyers that they have been called farm scavengers. For greatest profit, however, they can not be left to weeds alone the whole year.

Breed to Select. The breed of sheep to select for the farm flock will depend upon the relative market value of mutton and wool. Under normal conditions one of the standard mutton breeds will be found best suited to the average farm. Breeds of mutton sheep may be divided into two classes, (1) medium-wool and (2) long-wool breeds. Of the medium-wool breeds the Southdown, Shropshire, Cheviot,

and Tunis are in size smaller than the Oxford Down, Hampshire Down, and Suffolk Down. The long-wool breeds are all rather large. They are the Leicester (pronounced Lester), the Cotswold, and the Lincoln. The Rambouillet is a fine-

Figure 144.—Champion Southdown ewe.

wool breed. Choice among the breeds named is largely a matter of individual preference.

Conformation. No matter which of the above breeds is selected the form or type of animal will be much the same. It should be low-set, square and blocky, straight of topline and underline; should possess vigor and vitality as indicated by a short, broad head, large nostrils, and a clear full eye. It should have a short, thick neck, wide, deep chest, broad, level shoulders, smooth and thickly covered on top, and a muscular forearm. A broad, straight back with ribs sprung

wide from the backbone and thickly covered with flesh, a broad, thick loin, a long, level, broad rump, a deep, full twist, and a heavily muscled leg of mutton are all essential to a good mutton form. The legs should be short and straight, with bone dense and large though not to the point

Figure 145.—An aged Shropshire ram.

of coarseness. The flesh should be firm and evenly placed all over the body; the skin should be moist, thin, flexible, and pink except in the dark skinned breeds; the fleece should be long, fine, dense in some breeds, bright, even, and uniform of crimp, and should carry plenty of yolk, or oil, which keeps the wool soft.

Breeding. On the average farm, grade ewes will perhaps prove just as profitable as pure breds. The ram, how-

ever, should without question be a pure bred, registered animal of the best form and breeding.

The breeding ram should have access to all the good alfalfa or clover hay he will consume and enough grain to keep him thrifty and vigorous.

Figure 146.—A Cheviot ram.

Ewes should be bred to lamb any time after the middle of March depending upon the severity of spring weather and upon the shelter afforded by the lambing quarters.

Lambing requires the presence of the shepherd both day and night. If proper care has been given the flock during the winter, the majority of the lambs will be strong and vigorous. Occasionally a ewe will need assistance or the lamb may need to be helped to its first meal. Many lambs have been saved by being held up long enough to get a fill of warm milk. As the lambs come each ewe and her lamb should be

put by themselves for a day or two to avoid danger of the lamb's becoming lost from its mother or injured by the other sheep. This can be done by either building in small per-

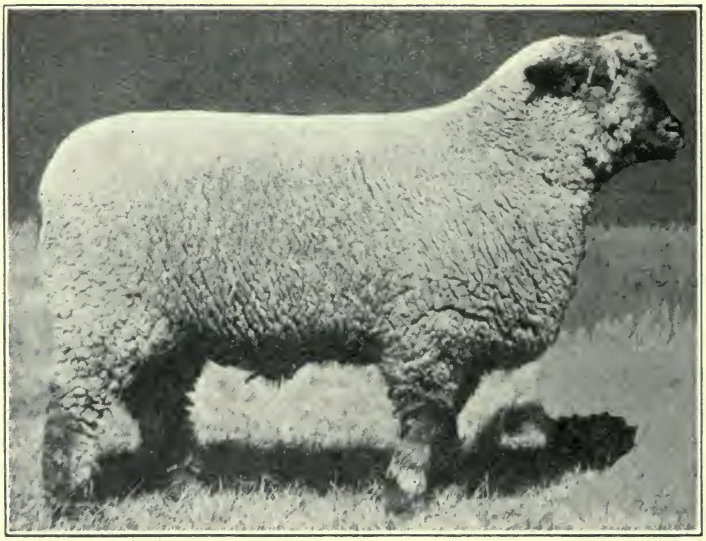

Figure 147.—A champion Oxford ram.

manent lambing pens, or by making, in one end of the lambing quarters, temporary stalls of small hinged hurdles.

Spring Care. It may be necessary in the early spring, while the ewes are milking heavily and before the pasturage is very abundant, to give the ewes a little grain. The flocks should be changed to a fresh pasture about once a month during the summer to prevent their becoming infected with stomach worms and other parasites.

Summer Care. Plenty of good upland pasture is about the only feed necessary for the flock during the summer. Low, damp pastures or damp quarters of any kind are a menace to sheep. Since sheep enjoy some browsing, a

pasture containing some shrubs or low trees is so much the better. A pasture should have at least enough trees and brush to supply abundant shade. Pure, fresh water and salt are necessary in order that the flock may thrive. If pastures are short, they may be supplemented by planting small

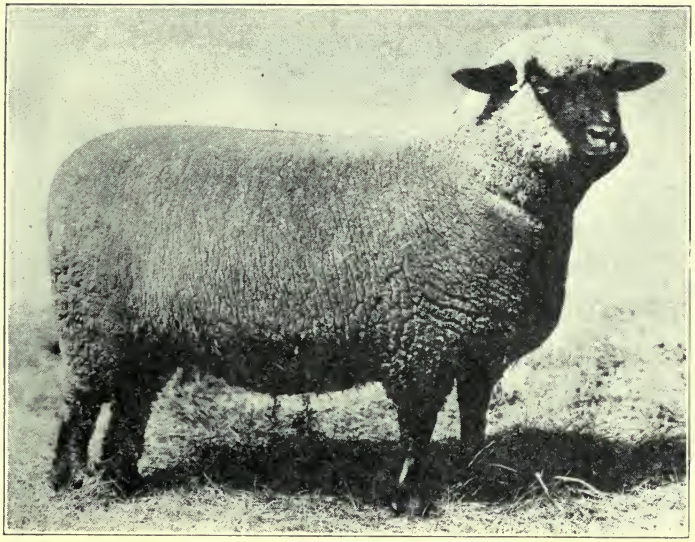

Figure 148.—A Hampshire ewe.

areas of various crops such as rye, barley, oats and peas, or rape (rape is highly recommended for this purpose) that the sheep may pasture off.

Feeding Lambs. At the age of one or two weeks the lambs will begin nibbling at their mother's feed. Now is a good time to provide a little extra grain for them where the ewes cannot get at it. This is conveniently done by making a lamb creep in one corner of the barn. This consists of a slat fence with the slats far enough apart to permit the lambs to pass between and yet close enough to keep out the ewes.

A trough in which grain is kept is placed behind the creep. One of the most satisfactory grain mixtures for lambs, under western conditions, is composed of one or two parts of bran to one part of oats, crushed oats preferred. A little finely ground corn or barley meal may be added occasionally for

Figure 149.—Leicester yearling ewe.

variety. A few roots, if they can be kept this late, are relished by the lambs.

Winter Care. While elaborate and costly buildings are not necessary for sheep, provision should be made to keep them dry above and under foot, and to prevent their lying in draughts. Warm quarters, however, are not necessary, as the sheep's coat is ample protection against cold. Plenty of room in which to exercise should be provided for the flock and the quarters should admit as much sunshine, light, and fresh air as possible. A good deep shed, open to

the south, built on a well drained spot, is about as profitable a building as can be made for wintering the flock.

Care of Ewes. If good alfalfa hay is available, little else need be fed to the breeding flock except that during the

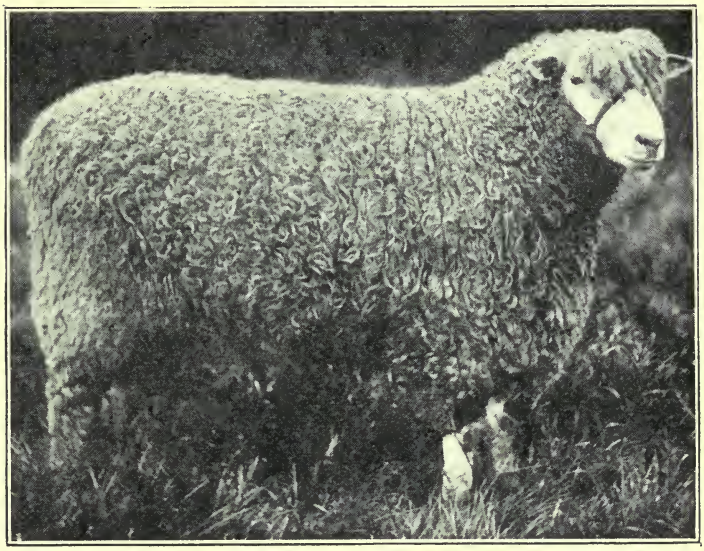

Figure 150.—A typical Lincoln ewe.

winter a few roots make a valuable addition to the ration. This statement may seem strange, but the flock of breeding ewes at the Utah Agricultural College repeatedly winters on nothing but alfalfa with sometimes the addition of a few roots, and comes out in good condition in the spring. Wild and timothy hays have no place in sheep feeding. If some of the ewes are thin as they approach the time of lambing, it is well to give them a small allowance of grain. A mixture of oats and bran is as good as anything.

Shearing should be done in the spring as soon as warm weather sets in. This time will usually be long enough after

lambing to avoid harm either to the ewe or the lamb. If postponed till the weather gets hot, the sheep become very uncomfortable in their warm coats and lose flesh rapidly.

Dipping sheep is found to be beneficial from two standpoints; first, it destroys lice, ticks, scab, and other parasites

Figure 151.—A good specimen of the Rambouillet.

which worry sheep, and cause much waste in lack of growth; and, second, it promotes the health of the skin and furthers the growth of wool. To kill parasites, dipping carefully once a year is sufficient, but some flocks are dipped twice a year for the benefit of the wool.

The best time to dip is shortly after shearing. The wool is then short and consequently less dip is necessary. The dip is surer to get down to the skin, and less time is required for the sheep to drain and dry, lessening the danger from colds.

Dipping should be done in the forenoon of a warm sunny day, thus allowing time for the fleeces to dry out before night. The dip should be warm (about 95 degrees F.) in order that it may penetrate the wool well and not chill the sheep. The sheep should be wet all over at least once and be kept in the dip about two minutes.

There are several kinds of dips that may be used successfully. Chief among these are lime and sulphur, tobacco dips and coal tar dips.

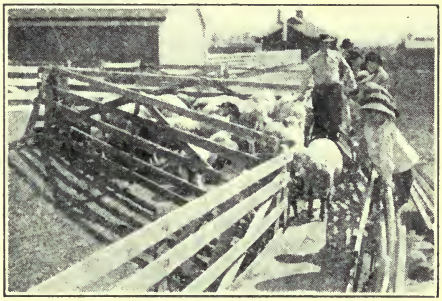

Figure 152.—Movable pen made of hurdles used in connection with dipping plant.

Dipping Plant. The kind and size of dipping plant will depend upon the size of the flock. If space and money permit and the size of the flock justifies it, a permanent plant may be put in, consisting of corrals, a chute, a concrete vat about 30 feet long heated by steam coils, and a draining pen arranged to return the dip to the vat as it runs off the sheep. A cheaper plant that is used successfully on many farms, though less convenient than the one mentioned above, consists of a corral made of hurdles, a plank walk leading to the vat, a galvanized iron vat, and a draining pen. All except the draining pen may be made movable, allowing them to be put out of the way when not in use.

QUESTIONS

1. Give three points in favor of keeping sheep on the farm.
2. What factors will govern the selection of the breed of sheep to keep on the farm?
3. Describe in some detail mutton form in sheep.
4. What care should be given the breeding ram?
5. What special care is necessary at lambing time?

6. How can lambs be given grain when the ewes are not being grain fed? Why should this be done?
7. Outline a winter ration for breeding ewes.
8. Of what value is dipping sheep?

EXERCISES AND PROJECTS

1. If near a shearing corral, weigh individual fleeces as they come from the shearer. Note age and breed of sheep and date of last shearing. Measure the length of the wool, and observe its fineness, strength, quality and amount of dirt and grease.

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CHAPTER XLI

POULTRY

The poultry industry of the United States has increased enormously in the past ten years, yet the price of eggs and of market fowls has nearly doubled during this time. The present value of this product exceeds that of many of the other farm crops. The size of the flocks varies from half a dozen hens, kept in a back yard or city lot, to twenty or twenty-five thousand hens on some of the large commercial farms, the average Utah flock being only forty hens. Poultry production may be in combination with various other crops or it may be special business. As a rule the fowls are most profitable when kept in small flocks on the general farm. The commercial poultry man produces only about ten per cent of the output of the United States.

In the poultry business it is a good plan to start with a small number; perhaps in the spring a setting of eggs, or a dozen baby chicks; or starting in the fall, with pullets or older hens, would be best for one who has had but little experience. Some knowledge of their care may be gained before the hatching and rearing season is on.

Little time is lost before the eggs or meat is ready for market. Very quick returns are received from the money invested. Many cases might be cited where the net value of the eggs produced by a flock of fowls by the time they were one year old was more than the entire cost of feed and house and original cost of the fowls themselves.

Choice of Breeds. There is considerably more satisfaction and greater opportunities in breeding pure-bred fowls than the ordinary mongrel stock. It makes little difference which of the popular breeds a person selects, provided that

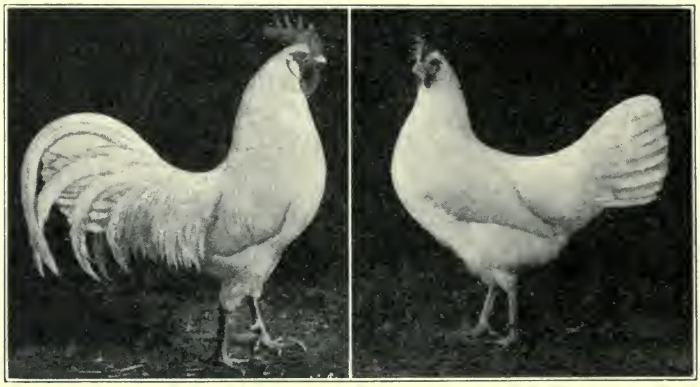

Figure 153.—Single-comb White Leghorns.

the fowls are hardy, from a good strain and adapted to the condition and purpose for which they are kept. It could not be regarded as good judgment to start a flock, the special object being to produce soft roasters, with one of the small nervous and very active breeds; nor in the egg business, with the very large clumsy slow-maturing breeds. For convenience, the different breeds are grouped into (1) egg breeds, (2) meat breeds, (3) general-purpose breeds, and (4) fancy

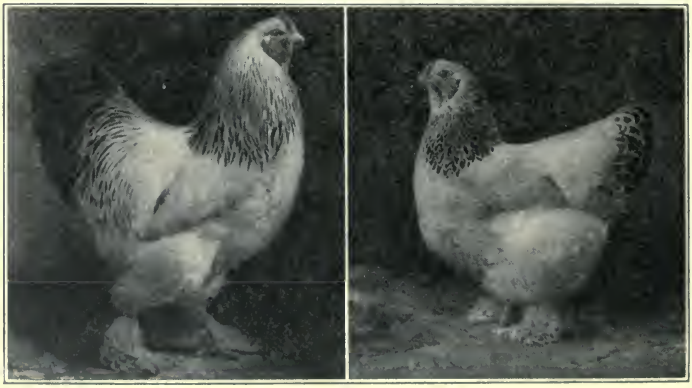

Figure 154.—Light Brahmas.

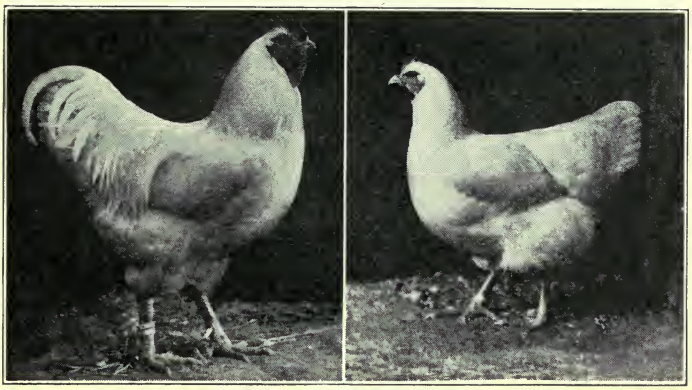

Figure 155.—White Plymouth Rocks.

breeds. No two breeds have the same characteristics, but there is a general blending of these useful qualities from one extreme to the other.

The Egg Breeds. This group includes all the small, nervous, active, less reliable sitting breeds that usually do not take on flesh readily and are rather hard to confine.

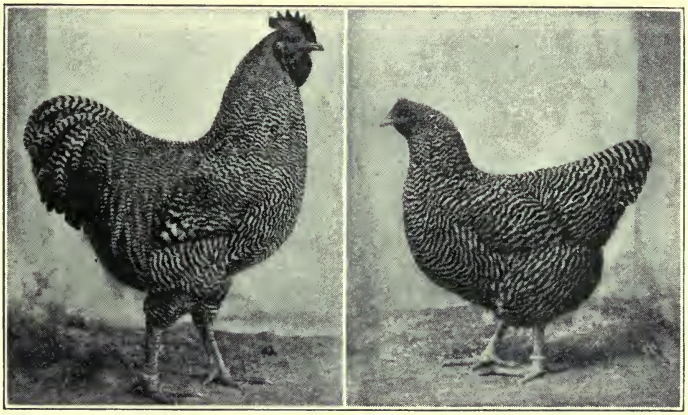

Figure 156.—Barred Plymouth Rocks.

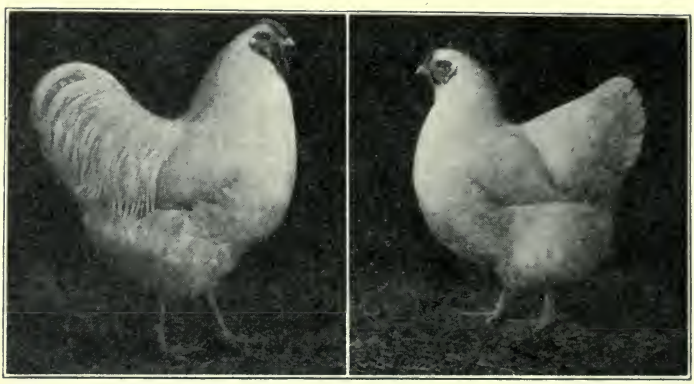

Figure 157.—White Wyandottes

Too often, when supplied with a setting of good eggs, they leave the nest before time for the chicks to hatch, or make very poor mothers after the chicks are hatched. They are excellent foragers and will range over considerable territory if given the opportunity to do so, yet will do fairly well in close confinement. They are usually hardy and develop very rapidly. Pullets often begin laying when only four and a half or five months old. The Leghorn, Minorca,

Figure 158.—Silver Wyandottes.

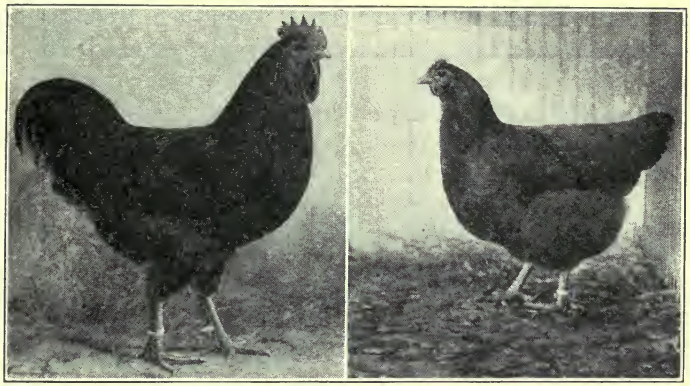

Figure 159.—Single-comb Rhode Island Reds.

Hamburg, Spanish, Ancona and Andalusian are the most common fowls of this group. Of the many varieties of these breeds the Single-comb White Leghorn is the most popular especially on the large commercial egg farms.

The meat breeds are large, awkward in their movements, sluggish, easily confined, persistent sitters, and poor foragers. They are gentle, easily handled, and take on flesh readily, yet mature rather slowly. One of the problems in

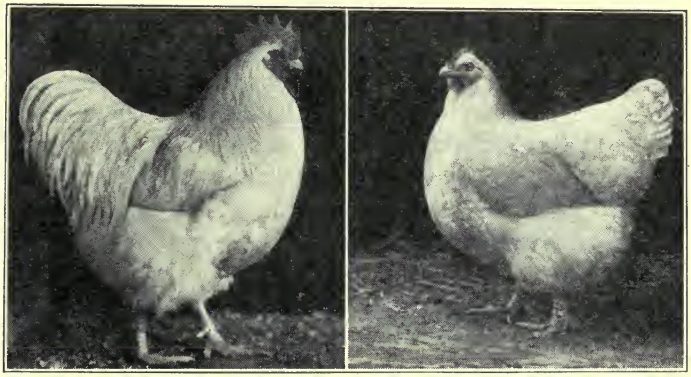

Figure 160.—White Orpingtons

the management of these fowls is to keep them from getting too fat for good egg production. They are of Asiatic origin and have feathered legs.

The Brahma is the largest and most popular breed of this group. Since Cochins are usually weak and of low vitality

Figure 161.—The hen is an efficient machine for transforming raw food into a very highly nutritious product.

and have little economic value, the Langshan is the only other breed of this group that is usually regarded as having much utility value.

The General-Purpose Breeds. In America and England these two extremes have been brought together, and through crossbreeding and careful selection a number of breeds have been developed, having many of the desirable characters of each. The general-purpose fowls are gentle when properly handled, make good sitters, excellent mothers, and good foragers, and yet are easily confined. When skillfully managed they lay well or will take on flesh readily. Of the American breeds, the Plymouth Rocks, Wyandottes, and Rhode Island Reds are the best farm fowls. The most popular English breed of this group is the Orpington.

The Fancy Breeds. In this group are classed those fowls having little or no utility value, such as the Games and Ban-

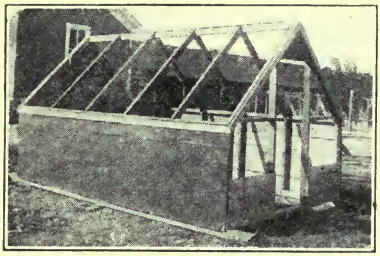

Figure 162.—Showing the framework of a movable gable-roof colony house. This type of house is not as easy to ventilate as the shed-roof house.

tams and many other fowls known for some peculiarity.

Location and Housing. A dry, well-drained sandy or clay loam with a south exposure is best for the location of the poultry house. This soil warms up early in the spring, produces an early supply of green food for the fowls, and does away with the necessity of floors in the houses. Wet or damp conditions within the house not only greatly reduce the disease-resisting power of the fowls and afford a favorable environment for some of the worst diseases and enemies; but a large percentage of the eggs produced are smeared with filth from the feet of the hens.

An abundant supply of fresh air without draughts is very important; yet the house must afford protection from the severe freezing weather. Cold, pure air is better than warm, impure air; yet it is the fresh air and not the low temperature that is desired. The shed-roof house with the open or curtain front is most common. With this type of house the other three sides must be tight during cold weather to prevent draughts. A curtain of thin muslin is commonly used to cover the opening during the cold nights. This is raised during the day to admit the rays of the sun which aid greatly in keeping the interior dry.

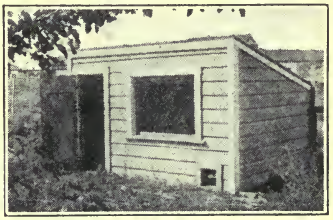

Figure 163.—The shed-roof house with open front provides good ventilation and sunlight.

Feeds and Feeding. When properly managed there is little or no danger of overfeeding the laying hen. Lack of the

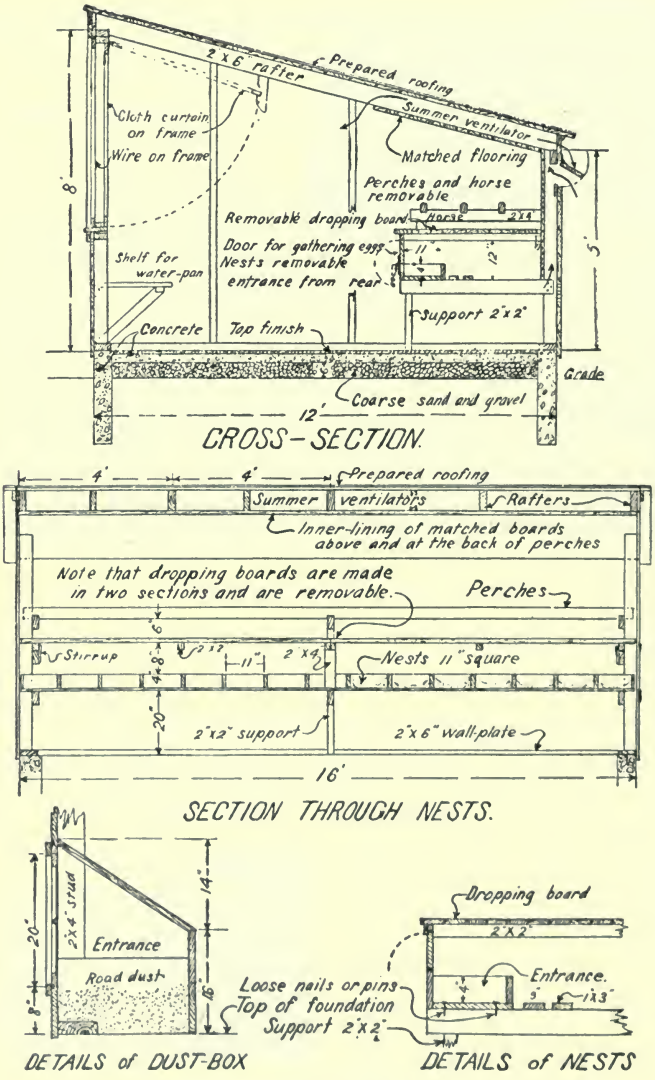

Figure 164.—Showing in detail the interior of a well-arranged poultry house.

proper amount and variety of feed shows first in decreased egg production. If only sufficient feed is given to maintain the body functions, there will be no eggs produced. The number of eggs laid is often determined by the amount and kind of food available. When fed correctly, all food above

Figure 165.—Poultry colony house

the amount required to keep up the body is manufactured into eggs with no increase in the weight of the fowl.

Fowls running on the farm with little or no attention will lay a large number of eggs during the spring months. The feeds of this season indicates in a general way what is necessary for egg production. The industrious hen will find seeds of all kinds in various stages of sprouting, also insects and worms, and young tender grasses and roots. During the fall and winter a good ration would contain a scratching feed and mash as follows:

Scratching Feed		*Mash*
Wheat 60 parts	Bran 100 parts	Chopped barley 50 parts
Corn 20 parts	Shorts 100 parts	Chopped alfalfa 10 parts
Oats 10 parts	Chopped corn 50 parts	Beef scraps 50 parts

Whole grains should be scattered in a deep litter of straw, morning and night. Dry mash should be kept in the hoppers at all times, and a feed of mash moistened with buttermilk

fed at noon. Fresh water, crushed oyster-shell, coarse sand and sugar beets, or other succulent feeds, ought to be available at all times. A limited amount of ground green-bone fed three or four times a week will increase the amount of protein. Since this food spoils readily in warm weather, it is used only during the winter.

There is a very high percentage of protein in eggs. A hen in heavy laying condition is not able to use the vegetable protein as an entire source of supply for this part of the egg. Some animal food, such as insects, skimmed milk, buttermilk, or meat scraps, to supply this, must be included as a part of the ration.

Green and succulent feeds, such as alfalfa chopped fine or ground, are very good. Clover or any of the legumes are good if not too old and woody. Sugar beets and mangel wurzels are the best of the root crops for winter feeding. The whole beet may be hung on a nail to allow the fowls to pick at it and eat as they choose, or it may be chopped fine and fed in the mash. Stimulants, such as peppers, mustard, etc., are good to tone up the digestive system when the fowls are run down, or weakened, but there is great danger in their continued or excessive feeding.

Incubation and Brooding. Eggs, when laid by good vigorous hens running with a good cock, furnish all that is necessary for a young chick, except the proper temperature. The application of this heat under favorable conditions is commonly called incubation. There are two ways of hatching chicks,—by the natural process with the broody hen or artificially with an incubator. In either case success depends on the vitality and constitutional vigor of breeding fowls, together with the conditions under which the eggs are kept and the process of incubation. Eggs for hatching should be kept in a clean place where the temperature does not go above 60 degrees or below 40 degrees and should not be more than ten or twelve days old.

Natural Incubation. The selection of the hen and the construction of the nest are the most important factors in natural incubation. A hen from one of the general purpose breeds, in a quiet secluded nest away from the other fowls, and dusted thoroughly with a good lice powder, will do well. Make a good roomy nest in the place selected. Move the broody hen to this nest at night. China eggs or unhatched eggs of other hens can be used for two or three days to see if she will accept the nest made for her. If she does, fresh eggs may be put under her. Whole wheat and corn, fresh water, and grit, comprise a good daily ration. If the nest is made in a box or up off the ground, four or five inches of damp soil or an inverted sod should be placed in the bottom and the nest material on top of this so as to prevent too much evaporation from the eggs. If three or four hens are set at the same time, the eggs may be tested by holding them before a strong light on the sixth or seventh day and enough infertile eggs taken out to permit one hen to be reset on fresh eggs.

Artificial Incubation. The incubator has made possible the large central hatchery and the large commercial poultry farms. A good incubator requires little time and attention to operate it. When once set and adjusted it regulates itself. There are, however, poor incubators manufactured that require almost constant attention and are often a failure. The regulation of the heat and the control of the ventilation and moisture supply are the important functions of a good machine. There are two systems of heating, hot air and hot water. There are good and bad machines of both kinds. Each system has its advocates and some companies make both machines, that the operators may have a choice. In general, the best plan is to follow in detail the instructions of the manufacturers. For the climatic conditions of Utah more moisture and less ventilation than in the more humid sections give better results.

Artificial Brooding. A good brooder is simple in construction and easily operated. All parts of the brooder should be easy to clean and should have no dark corners. A fireless brooder, when well-made and properly managed, gives good results under dry conditions. Freedom from moisture in the brooder is very essential to the successful rearing of chicks. Plenty of clean chopped straw, chaff, or other absorbent litter is needed in the brooder.

Chicks ought not to be fed until they are about forty-eight hours old. The first feed should be easily seen and nutritious. Bread and milk, hard-boiled eggs, bran, chopped wheat and corn, rolled oats with hulls removed, grit and lawn clippings or chopped alfalfa are all good. Feed often but sparingly the first few days. Mushy or wet feeds are undesirable, while an abundance of fresh water is essential. As much free, shady range as possible is advantageous.

Marketing. The annual loss in the handling and marketing of eggs in the United States is estimated at $45,000,000, much of which is due to poor methods used on the farm. One third of this loss is due directly to germ development called blood rings or heated eggs. This may be overcome by removing the male birds from the flock as soon as the hatching season is over, thus producing infertile eggs. Eggs should be gathered twice daily during the summer, put in a cool dry place, and marketed at least once a week. Small, cracked, or soiled eggs may be used at home while fresh. Grading the eggs into lots of uniform size, color, and shape will increase their value in the market.

The method of killing and dressing has much to do with the price and keeping qualities of fowls. They should not have feed of any kind for twenty-four hours before they are killed. All fowls should be marketed undrawn unless the market demands drawn fowls. They should be bled by cutting the arteries in the upper part of the mouth, well back in the throat, and then brained with the same knife by run-

ning it through the roof of the mouth on the median lines just back of the eyes. If the feathers are then plucked immediately they will come out easily without tearing the skin. Fowls thus killed and dressed, and packed dry without washing, after being thoroughly cooled, will reach the market in better condition and keep longer than those that have been drawn, scalded, and washed.

QUESTIONS

1. How does the climate affect the cost of producing poultry products?
2. What is the best method of starting a flock?
3. What branches of the poultry business offer the best opportunities in your section?
4. What are the advantages of raising pure-bred rather than mongrel fowls?
5. Name the four economic groups into which the different breeds are arranged and give the general characteristics of each group.
6. Name the most important breeds in each group.
7. Name and discuss four important factors in the selection of eggs for hatching.
8. What breeds of chickens are best to use for sitting?
9. When and why should the egg being incubated be tested?
10. What are the important factors to consider in feeding baby chicks?
11. Why is grit necessary? What kind of grit is best for laying hens? For baby chicks?
12. Why is a variety of feeds best for chickens?
13. What are the causes of the great loss in marketing eggs?
14. How can most of this loss be prevented?

EXERCISES AND PROJECTS

1. *Making an Egg Tester:* Take a shoe box or some other cardboard box about that size. Cut a round hole in the center of the lid or top about 1¼ inches in diameter. In one end of the box cut a narrow slit in the center from the top down two inches. Pass an electric light cord through this slit, globe inside; turn on light; put on lid and tie a string around to hold it on. The globe should hang inside just opposite hole in lid. Pull down

the window shades and hold an egg—large end up—in the hole in the lid so the light will shine through it. Turn egg back and forth on long axis. Does the yolk turn with the shell or remain somewhat stationary?

2. *Testing Eggs:* Get at least a dozen eggs—some fresh, others two, six and several days old; or, better, get part of them from under a broody hen or from an incubator where they have been incubated about six to eight days. Note first a fresh egg, both brown and white-shelled eggs where possible. Can you see the air cell? How large is it? Note the difference in size of air cell in fresh eggs and the other eggs. If eggs have been incubated, can you see the developing chick? Are any of the incubated eggs clear, similar to the fresh egg, except for slightly larger air cell? If so, they are infertile.
3. Visit a poultry farm having pure-bred chickens. Study the color, shape, and markings of the chickens. Learn to know them by sight. Are the hens, pullets, and roosters the same color?
4. Collect pictures of the common poultry breeds.

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CHAPTER XLII

THE FEEDING OF ANIMALS

The function of all farm animals is to utilize the rough food material that people cannot eat, and to change it into something useful to mankind, as, for example, the work of the horse, the meat and wool of the sheep, the meat of the beef animal, and the milk of the dairy cow. When we consider that all these products, which are so necessary to mankind, are made chiefly from the coarse feeds, worthless for human food, we begin to appreciate how important our animal friends are as factories to concentrate low-grade materials. Whatever animals produce must come from the feed they eat.

Classes of Food. For the best results with any of our farm animals great care must be taken in the kind and amount of feed we give them. All feeds are made up of groups of substances which differ from one another in certain ways; yet each group is the same no matter in which feed it is found, whether in hay, grain, grass, carrots, beets, or any other feed.

Water and Dry Matter. There is a certain amount of water in all feeds. This varies from sixty-five to ninety per cent in roots, pasture grasses, green alfalfa, and other green hays and fodders, to as low as seven to twelve per cent in the different grains, dry hays, fodders and straws. The first division, then, is the separation of the water and dry matter of feeds.

Protein. The dry matter may be classified into four groups known as food nutrients: (1) Proteins, (2) carbohydrates, (3) fats, and (4) ash. Protein differs from all the others by containing the chemical element, nitrogen, in

addition to carbon, hydrogen, oxygen, and some others. Lean meat, the white of eggs, and the curd of cheese are protein foods for mankind. Such feeds as alfalfa and clover hays, peas, bran, and oats, contain a relatively higher proportion of protein than wild and timothy hays, straw, corn fodder, corn, barley, and wheat.

Carbohydrates occur in feeds in a variety of forms. The various sugars and starches are examples of pure carbohy-

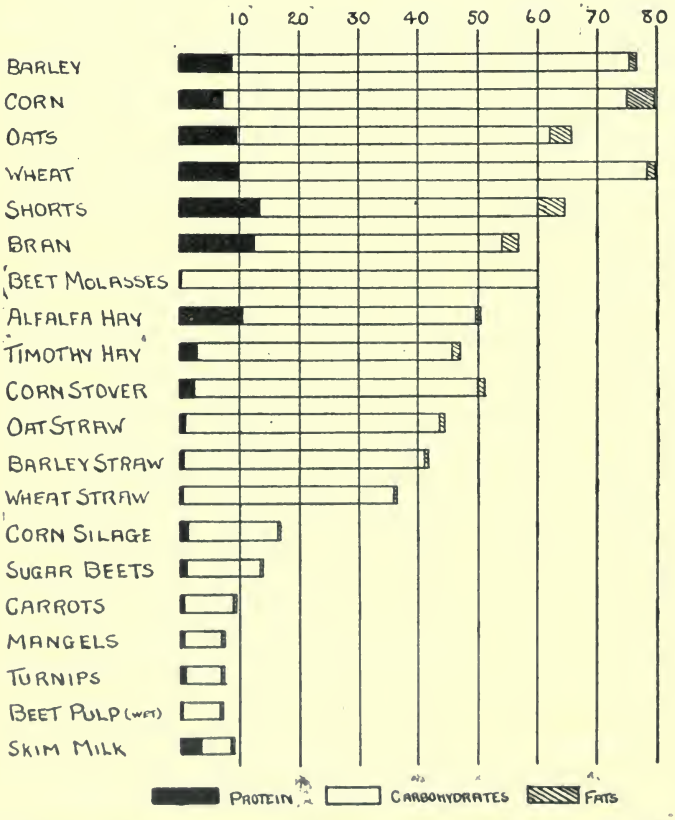

Figure 166.—Digestible nutrients of some common western feeds in per cents.

drates, and the coarse woody parts of plants are composed largely of a mixture of other carbohydrates. Only three chemical elements, carbon, hydrogen and oxygen, enter into their structure. Carbohydrates are used in the body to produce fat, heat, and energy to be used by the body processes or in work. They enter very little into the building or repair of the body.

As examples of carbohydrate feeds may be mentioned the grasses, grass hay, straw, corn fodder, rye, barley and corn.

Fats. The same chemical elements are found in fats as compose carbohydrates and they are used in the body for the same purpose. The elements, however, occur in such different proportions that fats are worth to the animal about 2.25 times as much as carbohydrates.

Ash. When any plant or animal matter is burned, there is left behind an ash, composed of various inorganic, or mineral elements, which were a part of the original tissue. This ash, or mineral matter, occurs in very small amounts in feeding material. It is, however, very important in feeding of animals. It is used chiefly in the construction of the bones, though each cell and fluid of the body must be supplied with a small amount of ash or disturbances set in which may cause death.

Digestibility. Some of the nutrients are so firmly locked up in the coarse, woody portions of the plant that they escape the dissolving action of the various digestive juices. Only the dissolved portions of the feeds are of any use to the animal, the others passing unused out of the body.

Many factors affect the proportion of each nutrient digested, the two chief ones being the kind and condition of the feed and the kind of animal fed. Hays and fodders are less completely digested than grains and other concentrated feeds. Horses and hogs usually digest less of the nutrients of any given feed than do cattle and sheep, especially of the coarser feeds.

A Good Ration. It is the business of the good feeder to supply that ration which will produce the greatest quantity of a high grade product and at the same time keep the cost of the ration as low as possible. To do this best requires great skill and a thorough knowledge of animal life and plant composition. No amount of theory, however, can take the place of intelligent observation in the barn and stable. The two must go hand in hand for best results.

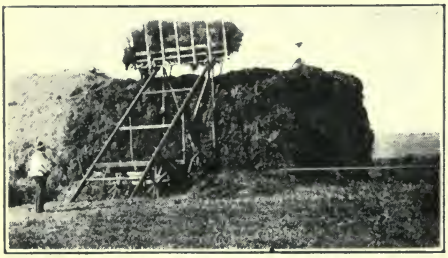

Figure 167.—Stacking alfalfa hay for feed.

A Liberal Ration. A ration should be liberal; that is, it should contain sufficient total feed for the requirements of the animal. The first use food is put to by the animal is to keep its own body alive and in normal working condition. If anything is expected of the animal in addition to this, in the nature of work, meat, wool, milk, or eggs, additional feed must be given.

In order, then, that the best results may be obtained the ration must be liberal enough to keep up the animal body and also supply material for the animal to manufacture the product for which it is kept.

A Balanced Ration. A ration must contain a certain amount of protein, or muscle-building material, in a proper proportion to carbohydrates and fats, or, in other words, it must be balanced. Protein is essential to the life of all animals. It is necessary in the repair and growth of all lean meat, tissues, and the blood, and in the production of milk, eggs and other animal products. Even with an abundant supply of the other food nutrients—carbohydrates, fat, and ash—the animal will die without protein. The amount of

protein necessary for best results depends upon the kind of protein, the kind of animal and the purpose for which it is fed. Chickens require a higher proportion of protein than most other classes of animals; a growing calf requires more protein in proportion to size than a fattening steer.

Adaptation to the Animal. The ration must be adapted to the kind of animal fed. For example, chickens cannot be fed entirely upon coarse hays and fodders, while such is possible with cattle and horses under certain conditions. A successful hog ration is not a profitable one to feed horses.

Palatability. A ration for best results must be palatable. An animal must be induced to consume large amounts of feed in order that the product may be correspondingly great. To encourage this large consumption, the feeds must be of the kind and in a condition which will appeal to the appetite of the animal. Coarse, tasteless feeds cannot be used entirely when feeding for the highest production. A variety of feeds is usually the best means of stimulating the appetite.

Quality of Product. A ration should also be made up with reference to the quality of the product. The influence of feed upon the composition of lean meat is not very well understood. It is well-known, however, that certain feeds influence the flavor of milk and the flavor and composition of butter. Among these may be mentioned wild garlic, parsnips, and potatoes. Leaner pork is continually being called for, and of course it will be to the advantage of the feeder to keep this in mind and feed to produce the grade of product most in demand. Many experiments have shown that feed may influence the quality of pork. Corn, when fed in excess, produces a soft, low grade of pork; wheat middlings, beans, peanuts, and acorns, when fed in large quantities, have a tendency to produce an oily pork. Field peas seem to produce pork too dry to be first-grade.

Economy of Ration Used. A ration should be economical. After all, this last requirement is the one of chief importance.

A ration may have all the characteristics given above, and yet its cost may be so great as to make its use inadvisable. Home-grown feeds are usually most economical and, on this account, should generally form the greatest part of the ration, even though such a ration might lack some of the desired characteristics. In the West, most rations will contain more protein than is thought to be necessary, because a large part of the protein is supplied in a relatively cheap feed, alfalfa, which forms the basis of most western rations.

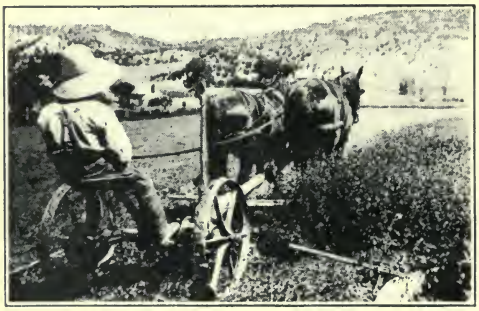

Figure 168.—Alfalfa hay in the making.

Feeding the Animal. Cleanliness is absolutely essential to the successful feeding of all classes of animals. The feeds should be clean, and great care taken to keep the mangers, feed boxes, etc., clean. All classes of animals will do better if fed and cared for regularly. They come to expect their care at certain times and are ready for it. Sudden changes in the ration should always be avoided, as digestive disorders may result from them. Never feed more at any one time than the animals will clean up.

Animals should have access at all times to a supply of pure, fresh water, and a liberal supply of salt. Kindness is most important in the treatment of all stock. It is pitiable to see an old cow with a large udder full of milk being hurried home from pasture with a dog at her heels, and her udder swinging from side to side at every step.

Horses. Alfalfa hay is without question the best hay for most horses, though for driving and race horses some kind

of grass hay may be more desirable, because it is less laxative. Experiments have shown that less grain is required with alfalfa hay than with the grass hays. About two thirds of the hay ration should be fed at night and one third in the morning, with little or none at noon. As a grain, oats takes first place, though bran and bran and shorts have been fed

Figure 169.—Corn has come to be recognized as an important crop for the silo in the West.

successfully to horses at slow work. Corn, barley, and wheat may also be used where available.

Throughout most sections of the West there is a tendency to feed too much hay to horses. Alfalfa hay is very palatable and as a result horses will consume too much if it is not restricted. This overconsumption, besides being wasteful, results in laziness and lack of spirit in the horses and frequently brings on digestive disorders. From one to one and one quarter pounds of hay and three quarters to one pound of grain per one hundred pounds live weight is a good basis from which to begin the calculation of a ration for the average horse. A sixteen hundred pound draft horse would, therefore, be fed from sixteen to twenty pounds of alfalfa hay and from twelve to sixteen pounds of grain daily.

Dairy Cows. In the winter feeding of dairy cows, summer conditions should be imitated as closely as possible. There should be, therefore, an abundant supply of palatable,

succulent feed, and the cow should be kept in warm, comfortable quarters. Alfalfa hay should form the basis of the ration, though this, for best results with good cows, must be supplemented with some grain and roots or grain and silage. The silo has long been successfully used on eastern dairy farms and in recent years silage has proved a most valuable addition to the dairy ration in many sections of the West.

For the smaller cows a ration made up of eighteen to twenty-five pounds of alfalfa hay, twenty-five pounds of silage and from three to eight pounds of grain has given good results. For the larger cows the hay should be increased to from twenty-five to thirty-five pounds and the silage to thirty pounds. Grain should, of course, always be fed according to the amount of milk and butter-fat produced.

In summer about all that is necessary is a good pasture. It is, however, advisable to have dry alfalfa hay before the cows at night, so they can supplement short pastures or make up for time lost in fighting flies. A small allowance of grain in addition to the pasture and hay will be found profitable for heavy producing cows.

Beef Cattle. Where marketing facilities and cropping system will permit, beef cattle can be profitably fattened on western farms. Here again alfalfa hay will form the basis of the ration. From three to ten pounds of grain per head daily will probably be found sufficient. Where silage is available from twenty to thirty pounds of this will be an excellent addition to the ration.

Barley or a mixture of barley and bran will in many sections be found the most economical grain to feed. Any of the grains are good if obtainable at reasonable prices.

Sheep. For summer feeding of sheep a good pasture or range is all that is necessary. Usually all that is required, in addition to good winter range, is alfalfa hay, save when the sheep are to be fattened for market. Barley is the grain

most frequently fed in the West to fatten sheep. A practical ration for fattening lambs consists of what alfalfa hay they will clean up well and three fourths of a pound of barley per head daily. Lambs fed on this ration or on some other grasses and grains show a good average daily gain.

Both cattle and sheep are fattened in large numbers near sugar factories where green beet pulp is available. The

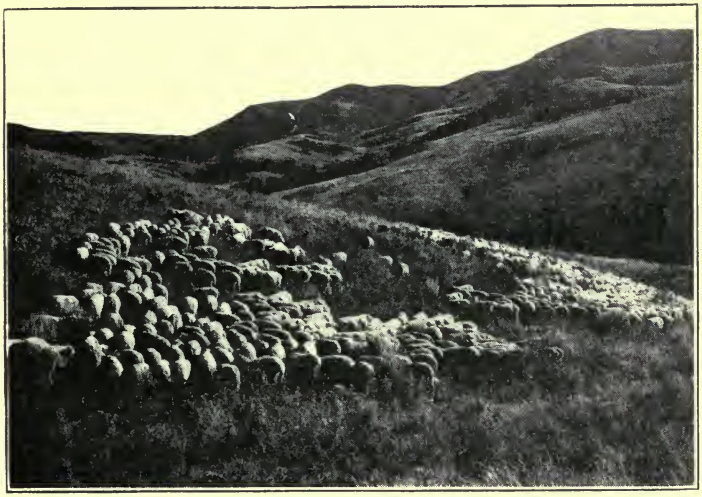

Figure 170.—The mountains of the West supply an abundance of nutritious food in summer.

ration for cattle is made up of a limited allowance of hay, grass hay being frequently used, from one to five pounds of grain, and what green beet pulp the cattle will consume. More than one hundred pounds of the pulp per head daily is frequently eaten. A similar ration is given sheep, except that the daily grain allowance ranges from one half to two pounds per head.

Hogs. Hogs do well on good alfalfa, clover, or rape pasture in the summer, though they should never be made to depend on this entirely. From two to eight pounds of grain

per head daily in addition to the pasture may be fed with profit, the amount varying with the size of the pig and the object in feeding it—fattening hogs of course getting the most grain. In the winter hogs will eat considerable amounts of alfalfa hay, if fine. Roots and skim milk are also relished. Corn is perhaps the best grain to feed with alfalfa and roots, though barley and shorts may also be fed to advantage and will actually be found cheaper in many sections.

QUESTIONS

1. What is the function of farm animals? Illustrate how each is of value to man.
2. Name and briefly describe the six food nutrients.
3. How are the various feeds utilized in the animal body?
4. Give six characteristics of a good ration with reasons for each.
5. How should horses be fed for best results?
6. Why and how should a dairy ration differ from a ration for horses?
7. Discuss briefly sheep and hog feeding.

EXERCISES AND PROJECTS

1. Secure oats, wheat, barley, corn, rye, and any mixed feed on the market; quart measure and scales. Measure out and weigh one quart of each of the grains. Calculate the weight to the bushel.
2. With a tape measure or ruler measure a grain bin and determine its cubical contents. From the number of cubic feet in the bin, and in a bushel, and the weight of a bushel of the different kinds of grain as determined in Exercise 1, find the number of bushels and weight of each kind of grain which can be put into the bin.

   Note: There are 1.2445 cubic feet in a bushel.
3. Use a small bunch of alfalfa, clover, timothy, redtop, and wild hays, corn stover, and straw. Study each sample separately; note the relative proportions of leaves and stalks; the way the stalks branch; the coarseness of the stalks; the way the leaves are attached to the stalks; the ease with which the leaves are broken from the stalks; the ease with which the leaves are crushed. What relation has each of these to the dustiness and the quality of the hay?

4. To find the amounts of hay and grain consumed by the different kinds of farm animals, weigh the customary feed of hay and grain given to each of several animals. Note the kind, age, and size of the animals, and the kinds and amounts of feed.

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CHAPTER XLIII

THE CARE OF ANIMALS

Probably the most neglected and least understood part of the live stock business is the proper care of animals. Live stock is usually handled in a haphazard way with but little regard for system or detail, and, as a result, great losses are experienced yearly. According to a recent report of the Secretary of Agriculture, the loss of animals in one year in the United States alone, from disease and exposure, was, in round numbers, six and a half million swine, two and a half million sheep, two million cattle, and one half million horses and mules. The monetary loss is placed at $200,000,000 yearly, a startling waste of resources.

CAUSES OF DISEASES

Confinement in Close Quarters. With proper understanding of the care of animals many of the losses now experienced could be prevented. At one time, when the open range was plentiful and the live stock were allowed to roam at will over the country and select desirable food and protection, diseases were almost unknown. Artificial methods of feeding and housing bring on many disorders and diseases that were not known on the open range. Whenever animals are gathered in large numbers, there is an increased tendency toward disease, as their freedom is interfered with, and, instead of selecting their own forage, they are compelled to take whatever is supplied them—too much or too little food that is not of a nourishing nature, or that is spoiled. They may be housed in stables or barns that are poorly lighted and ventilated and that are often in a very unsanitary condition. Again, they may not be allowed free access to good

water at regular intervals. All these causes have a tendency to lessen the resistance of the animals and make them more susceptible to disease. Some of the common causes, then, of disease among live stock are poor feed, poor quality or irregular access to feed and water, poor ventilation or expo-

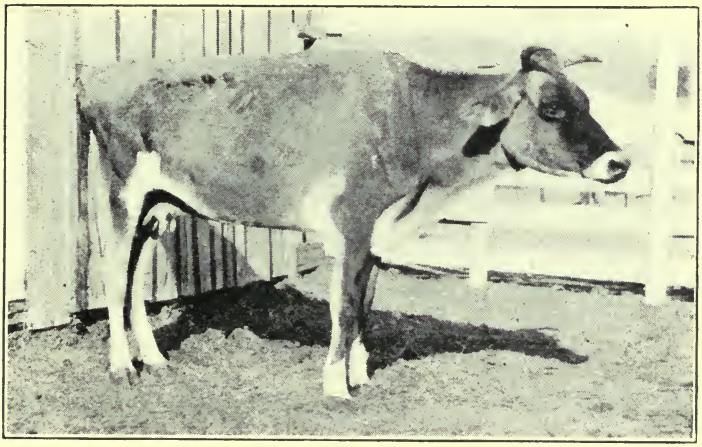

Figure 171.—A picture of trouble; a neglected cow

sure, lack of exercise, heredity, germs, parasites, and affected teeth and feet, mostly preventable by proper care.

Overfeeding. Animals that are overfed and allowed to become too fat are susceptible to disorders and disease and are not able to endure hard work satisfactorily. Horses are often given large amounts of feed just before they are compelled to perform hard work or go on a long journey, a practice which is extremely detrimental. The stomach, being small, is unduly distended, or the food is forced on into the intestines before it is acted on by the stomach juices. The animal body can take care of only a certain amount of nourishing matter; anything over this amount must be excreted. The digestive organs are taxed to their utmost to

digest the food and then the organs of alimentation are again taxed to get rid of the excess. In this way the animal soon wears out and breaks down. Unnutritious, bulky, or spoiled food overtaxes the digestive system.

It is also bad to feed much to warm or tired animals. Sudden changes of food may also bring on disorders. When

Figure 172.—Exposed horses; poor care.

heavy work is stopped, feed should be lightened up considerably in order to prevent trouble.

Poisonous Plants. Animals may get poisonous plants or roots of such plants in pastures or in hay, often overcoming them entirely or weakening their bodies until rather susceptible to disease.

Bad or Irregular Water. Where animals are worked from about seven o'clock in the morning until noon, in the hot sun, without being allowed a drink during this time, they often drink too much; and, if this water is cold, it tends to injure them. Work animals should be allowed water once or oftener during the half day, if possible. The person who drives the horses usually takes a drink at intervals during the half day and he should think of the animals at the same time. Horses would then stand more and be less liable to digestive troubles and other diseases. Water may

contain decaying animal and vegetable matter, parasites, bacteria, or minerals, all or any of which may prove injurious. Only pure water should be given animals at regular intervals as frequently as they require, according to the work.

Poor Ventilation. Some animals are compelled to stand in an ill-kept and poorly ventilated stable most of the time. To do so is equally detrimental, as animals require good fresh air and plenty of exercise. Resistance is weakened and many bodily disorders are contracted. Animals should also have protection from cold and wet.

Parasites. Animals are often affected by internal and external parasites which may lower their resistance and make them more susceptible to diseases. Among internal parasites are round worms, flat worms, bots, and liver parasites. These usually cause animals to become unthrifty, often making them susceptible to infectious diseases. Among external parasites are mange, itch, mites, ticks, lice, ringworm, and flies. Generous feeding is a good preventive for parasitic diseases, as it keeps the animals strong and healthy. Medicines may be oils that suffocate, poisons that kill, or irritants that devour or disperse the parasites. There is no one remedy for overcoming this trouble in all animals.

Germs. Contagious and infectious diseases are brought about by germs which usually enter the animal body through the digestive and respiratory tracts or through wounds and abrasions. Germs thrive best in filthy places, such as poorly ventilated or poorly lighted stables, where much manure has accumulated, or where there is decaying matter, wet soils, stagnant water, or unsanitary surroundings.

The Teeth. If one tooth does not come in proper contact with the one on the opposite jaw, there is nothing to wear it away, and such teeth grow out long and lacerate the tissues of the opposite jaw, causing severe pain and interfering seriously with the animal's eating. We may also find

sharp, decayed and ulcerated, split or broken teeth. These should be treated. Some men feed animals patent feeds or powders, expecting them to do better and lay on flesh, when there is nothing wrong with the animal except that its teeth are bad. The usefulness of the horse depends largely upon the teeth, because, if they are affected, the entire body suffers. Horses' teeth should be examined at least once a year by a qualified veterinarian. The general symptoms of affected teeth are unthriftiness in spite of good feed and no work, saliva dribbling from the mouth, often chewing the feed and then spitting it out again. Difficulty in chewing, holding the head sidewise, and chewing only on one side; drinking cold water very slowly, throwing head to one side, slobbering it from the mouth again; a swelling of the jaw, a refusal of food, fetid odors from the mouth, and manure containing undigested food, all indicate tooth troubles. For these indications a veterinarian is indispensable.

The Feet. Another absolute necessity in handling the animal is the care of the feet. The old adage, "No foot, no horse," is indeed a true one, because an animal with poor feet is not capable of carrying itself over the ground properly, and hence cannot perform its work efficiently. Care of the feet of colts is of especial importance, and abundant exercise on dry ground which is not too rough is most beneficial. The hoofs are thus worked gradually and uniformly. It is also necessary to keep the hoof clean by frequent and thorough washing and by bedding with plenty of good straw, if in the stable. Shoeing is a necessary evil. Owing to hard roads, the feet of work animals must be protected with shoes. After the feet are properly trimmed, the shoe should be made to fit the foot and not the foot to fit the shoe, as is too commonly the case. The frog should be left large and elastic, as nature has provided, to take off some of the concussion that would otherwise be transmitted to the body.

Too early shoeing of young horses is very injurious, as it hinders the development of the hoofs. Moderate work in the fields does not injure young horses, but for such work they do not need shoes. It is advisable to allow horses to go barefoot whenever possible, but the hoof should be kept trimmed.

Heredity. Such conditions as faulty conformation, bony blemishes, as ringbones and spavins are often transmitted from parent to offspring and develop sometime during the lifetime. The weakness is transmitted, not the disease.

PREVENTION OF DISEASE

Grooming. Grooming animals is the process of mechanically cleaning the skin and coat and of applying friction and massage to them. Grooming is a necessity for confined or working animals imposed on them by domestication.

Animals "turned out" require no grooming, as nature takes care of them, furnishing them with the coat that is necessary for their environment.

Proper grooming cleanses the coat and skin, stimulates the circulation, assists the action of the lungs, gives tone to the skin, and acts beneficially on the muscular structure. Especially should the legs and feet receive proper attention.

Neglect of grooming may bring on skin diseases, particularly the parasitic forms; it also allows wastes that are to be thrown off by the skin to be absorbed by the body, lessening the resistance of the animal and allowing greater chance for disease.

Disinfection. Disinfection is intended to check the spread of contagious diseases and to protect from further infection animals which may be already diseased. When a yard or corral is being disinfected, all the litter should be removed, the ground burned over with a layer of straw. Three or four inches of surface dirt may be removed, or the entire surface sprayed with some good disinfectant, such as

a five per cent solution of carbolic acid, creolin, or lysol. The same material can also be used for disinfecting the inside of barns or stables. Where there is considerable woodwork inside barns, corrosive sublimate is often used in from one to five per cent solution with hot water. Any germs exposed to direct sunlight for a length of time are destroyed. This is nature's method of overcoming injurious germs. Allow plenty of sunlight.

Quarantine. Where infectious or contagious disease exists the well animals should be removed from the diseased ones to clean dry surroundings. The infected premises should be cleaned up by thorough disinfection and all the dead animals properly disposed of. The well ones should be watched to see if any come down with the disease, and as soon as noticed removed to the sick herd.

When introducing new animals into a herd or flock, it is best to keep them quarantined for about two weeks to make sure that they are healthy, before allowing them to mingle with the other animals.

Disposal of Carcasses. All dead animals, especially if death was due to some contagious disease, should be burned or buried deep in the ground. The most effective method in burying animals is to put them about six or eight feet under ground and cover them with a layer of quicklime.

ACCIDENTS AND TREATMENT OF WOUNDS

Wounds and abrasions of the skin and of other parts of the body are often responsible for much trouble among animals, causing the resistance of the body to be overcome. The only way success can be obtained with wounds of any kind is to observe perfect cleanliness.

The blood should be stopped by the tying of the bleeding vessel with a piece of clean cord or silk or by applying clean absorbent cotton over the wound and then placing a roller bandage over the injured part. After all bleeding

has stopped the wound can be dressed by removing all foreign objects or hair that may be hanging on the wound, and cleaned with a mild antiseptic solution consisting of about a two per cent solution of creolin, carbolic acid, or lysol. It should then be covered with a drying powder consisting of equal parts of boric and tannic acid and about

Figure 173.—Cattle given natural and proper care.

one half part of iodoform mixed together, covered with absorbent cotton, and wrapped with a bandage. The wound should be dressed daily with the drying powder, clean cotton and a bandage until healing is well along.

QUESTIONS

1. Why are diseases of animals more frequent now than formerly?
2. List the causes of disease.
3. What dangers accompany overfeeding?
4. State the precautions considered advisable in watering animals.
5. Give the principal points concerning ventilation, cleaning stables, and grooming.
6. Describe the most common diseases and give control measures.
7. What is disinfection? When should it be practiced?
8. Discuss vaccination.
9. How should an animal's teeth be cared for? Its feet?
10. Give methods in caring for wounds.

EXERCISES AND PROJECTS

1. If it should so happen that a veterinarian is caring for an injured horse in the neighborhood, it might be profitable to watch him treat it.
2. If convenient to all concerned, visit a blacksmith shop and get him to explain as he shoes a horse.

   Note: Arrangements for both these exercises should be made with the men concerned.

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  380. The Loco-Weed Disease.
  439. Anthrax.
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  536. Stock Poisoning Due to Scarcity of Feed.
  540. The Stable Fly.
  666. The Foot-and-Mouth Disease.
  720. Prevention of Losses of Stock from Poisonous Plants.
  784. Anthrax or Charbon.
  790. Contagious Abortion in Cattle.

CHAPTER XLIV

SUGAR AND FLOUR

SUGAR

Long before the dawn of the Christian Era, cane and bamboo were cultivated for the sugar that could be extracted from them. The process of extraction was primitive indeed. The raw cane was used as food. From the fifth to the tenth century A. D. sugar was extracted and crystallized in small quantities and used by physicians as a medicine. Since then its use as a food has rapidly developed, and, though it was long regarded as a luxury to be enjoyed by the wealthy classes alone, it is now a necessity in every household.

Cane Sugar. The first sugar factory to operate successfully in the United States was built in Louisiana in 1791, and from that time until the beginning of the Civil War, the sugar industry maintained a steady growth in the South. A variety of cane had been found that flourished in the warm climate and on the fertile soil of the lower Mississippi Valley. The slave trade made labor cheap; as a result, large cane plantations could be managed at low cost. During the first half of the nineteenth century more than sixty per cent of the world's sugar supply was produced by slave labor, Cuba, Porto Rico, and our own Southern States leading. The abolition of slavery in America and the simultaneous development of the beet sugar industry in Europe operated as checks on the extension of sugar cane culture. At the present time about half of the world's production is from beets, the other half being almost entirely from cane, though a little maple sugar is still being made. Within the last ten years the amount of cane sugar annually pro-

duced has decreased about ten per cent, while the beet sugar production has increased more than twelve hundred per cent.

Louisiana. More than ninety per cent of all the cane sugar produced in the United States is raised and manufactured in Louisiana. The system governing the price paid for cane is unique. The farmers receive $1.00 per ton for cane for each cent per pound received by the factories for the sugar. Thus, if the wholesale factory price for sugar is 3c per pound, the cane is paid for at $3.00 per ton.

Hawaii and Cuba. The Hawaiian Islands are especially well adapted to the cultivation of cane. The average yield is thirty-five tons an acre and twice that amount is not unusual. No other country in the world has so high an average yield, and the percentage of sugar in Hawaiian cane is higher than the average anywhere else. Cuba cultivates a much greater acreage than Hawaii and exports more sugar than any other country. In 1909 Cuba produced 1,573,582 tons of cane sugar; Java, 1,241,885; Hawaii, 500,000 tons and Brazil, 248,000 tons.

BEET SUGAR

History. It was a German chemist, Marggraf, who, in 1747, first obtained sugar from beets. It was fifty years after this discovery was made before the first beet sugar factory was built. For fifty years more the sugar beet industry struggled for recognition, but found it almost impossible to compete successfully with the cane. Then modern methods, improved machinery, and a protective tariff came to its aid, with the result indicated as follows:

Beet sugar produced in Germany in 1836, 14,000 tons; 1877, 378,000 tons; 1886, 1,000,000 tons; and in 1906, 2,223,500 tons. The average extraction in Germany is 15.7 per cent and the cost of production two cents a pound.

The sugar obtained from beets is identical with cane sugar when both are pure. The impurities contained in the two sugars are different.

In the United States. Although the Alvarado factory was built in California in 1870 and has been in operation continuously since that time, the beet sugar industry amounted to very little in the United States prior to 1897. Since then the growth of the industry has been phenomenal. In 1892 the United States produced 13,000 tons of beet sugar; in 1897, 45,000 tons; in 1902, 281,406 tons; in 1910, 510,172 tons; and in 1914, 700,000 tons. The cost of producing beet sugar in the United States varies greatly in the different factories, depending upon the price of labor, price paid for beets, the composition of the beet and the efficiency with which it is extracted.

Figure 174.—Sugar factory, Logan, Utah.

Russia produces nearly 1,500,000 tons of beet sugar annually, but Germany leads with an annual production of 2,500,000 tons. In 1914, the six greatest sugar-producing states in this country, in order, with the number of factories, were, for (1) Colorado, sixteen; (2) Michigan, sixteen; (3) California, thirteen; (4) Utah, seven; (5) Idaho, five; (6) Ohio, five. In addition, there are sixteen factories scattered in other states making seventy-eight in all.

The United States produces annually more than a half million tons of beet sugar and almost as much cane sugar. In addition to this, we import approximately two millions of tons of sugar annually for which we send out of the country $130,000,000 every year. This cost of imported sugar added to the value of our home product makes the sugar bill of the United States one million dollars a day.

Storage Bins. Beets delivered at the factory are stored in long V-shaped bins. The floor of each bin is made in small movable sections and directly under the floor there is a sluice, or flume, through which a rapid stream of water flows. A section of the floor near the lower end of the bin is removed and the beets are allowed to drop into the stream below, which carries them to the mill, meanwhile freeing them from much dirt. They are removed from the stream by means of large steel flanges on a wheel that elevates them to the scrubber. The scrubber is a large tank filled with water and having rotating brushes or paddles that move the beets through the water to remove the dirt.

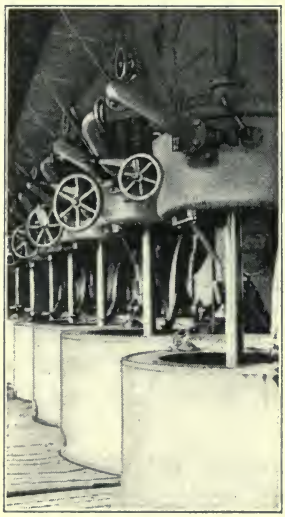

Figure 175.—Centrifugal machines in a sugar factory.

From the scrubber the beets are elevated by cups on an endless belt to the top of the mill where they are delivered to an automatic weighing machine.

Removing the Juice. The slicer is a large steel cylinder in which the beets are cut into long slender strips called cossettes. The cossettes are carried in an iron trough to the diffusion battery, which consists of from twelve to fourteen steel tanks or cells, each holding about two and one half tons of cossettes.

The sugar is dissolved out of the beets by a stream of warm water, which enters at the top of one cell, passes down through the mass of cossettes, up through a heating tube, and down through the next cell. The juice is piped from the diffusion battery to the measuring tank. When the sugar has been extracted, the remaining pulp is pumped to the silo and is used for feeding cattle and other live stock.

Purifying the Juice. The juice that accumulates in the measuring tank is a dark-colored, sweet liquid containing a high percentage of sugar mixed with various impurities. Milk of lime is added to the juice which absorbs a vast quantity of the impurities suspended in the liquid. Carbon dioxide, now added, unites with the dissolved portion of the lime, forming a white insoluble substance which settles, carrying with it much of the dark-colored matter.

The liquid is then pressed through canvas filters to separate it from undissolved lime and dark-colored impurities. These processes are repeated for further purification.

Sulphur is burned and the gas produced, known as sulphur dioxide, is passed into the juice. This combines with the lime in the solution, forming insoluble compounds which are removed by filtering through canvas.

Concentration. The liquid is now concentrated by boiling off a part of the water. The syrup passes to the crystallizing pan where the evaporation is continued. When the desired consistency is reached the mass flows into the mixer. In another vat the heavy brown mass is stirred until it is drawn off at the bottom into the rapidly rotating centrifugals, large steel cylinders with perforated linings. The water, carrying some sugar in solution, passes through the perforations, but most of the sugar remains in the cylinder.

Sugar Crystals. The crystals are scraped from the walls of the vessel and carried by elevators to the drier, which is a horizontal tube five or six feet in diameter and twenty to thirty feet long through which the sugar crystals are made to travel against a counter current of hot air. The sugar then drops down a chute or pipe to the sacker where it is placed in one-hundred-pound bags ready for the market.

The syrup that passes through the centrifuge is rich in sugar, and to avoid waste, is again concentrated in evaporators, and passed through centrifugal machines. The liquid passing the second centrifuge is also saved, and subjected to

another process known as the Steffens process, where another yield of sugar is obtained.

FLOUR

Our country produces yearly about 800,000,000 bushels of wheat and 12,000,000 tons of wheat flour. More than 10,000

Figure 176.—Flour mill elevator.

flour mills are in constant operation, employing 40,000 men.

In Utah there are sixty mills, producing annually more than two million dollars' worth of flour and hundreds of thousands of dollars, worth of graham, bran, shorts, rolled wheat and other products.

The quality of flour depends largely upon the kind of wheat used in its manufacture. For this reason the millers of the West pay a higher price for Turkey Red wheat than for any other variety. The quality is dependent also upon the condition of the wheat and the milling process. Careful reduction of the wheat and complete separation of the bran and flour are necessary for the production of good flour.

Milling of Wheat. Wheat, when received at the elevator, is freed from the chaff, dirt, shrunken kernels, and other

foreign material by fanning and screening it. It is then stored in a large building, the elevator, until wanted in the mill. The wheat then passes to the milling separator where it is given another treatment, very similar to the first, in which a more complete separation is accomplished. The grain then goes to the scourer, a rapidly rotating cylinder in which the wheat is thrown violently against the perforated walls of the machine. This agitation removes the fine hairs from the end of the kernel and the minute particles of dust held in the crease of the berry. An exhaust fan connected with the scourer removes this dust from the cylinder.

It is now ready for tempering. This consists in moistening the wheat with water and allowing it to stand from six to twelve hours to soften the outer part of the kernels in order that large flakes of bran may be secured with a minimum of dust. The amount of water added depends upon the kind of grain used, hard wheats requiring more water and a longer time for tempering than the soft varieties. Ordinarily water, amounting to two or three per cent of the weight of the wheat is used. After tempering, the wheat goes through a second scourer and then passes to the breaks.

The breaks are corrugated steel rollers between which the wheat is crushed. The broken wheat is sifted through screens, the coarser portions being sent to the second and third breaks and the finer material passing to the smooth rolls. After passing between the rolls, whether corrugated or smooth, the mass is separated by screens into portions of varying degrees of fineness, and each portion is sent to the other rolls set close enough to accomplish further reduction. Only that portion which passes through fine bolting silk is sold as flour. Ordinarily wheat yields from sixty-five to seventy-five per cent of its weight in flour and from twenty-five per cent to thirty-five per cent in bran and shorts.

Bleaching Agents. It has been the custom in some mills to bleach flour by such chemical agents as sulphur dioxide

or nitrogen peroxide. This practice has been condemned by food experts, because slight amounts of the bleaching agents are absorbed and retained by the flour. It is now contrary to the pure food law to bleach flour.

Flour Content. Flour contains high percentages of starch and protein, together with a little fat, and inorganic matter.

Figure 177.—Bread made of flour of various wheats.

These four types of food, carbohydrates (starch and sugars), proteins, fats, and mineral matter, are all that are required for the complete nourishment of the body.

The protein content (ten to eighteen per cent) of flour is made up chiefly of gluten, a name given to a substance composed of two distinct chemical bodies, one component called gliadin, which is responsible for the stickiness of dough; the other, glutenin, a tough, tasteless substance.

The strength of flour, that is, its capacity to absorb and hold water and its power of expanding under the influence of the gas (carbon dioxide), liberated in the dough by yeast; is dependent upon the quantity and character of the gluten present. Hard wheat yields flour much richer in gluten than soft wheat, because of which the loaves rise higher, thereby causing the bread to be lighter. Good flour, too, absorbs more water, making 140 pounds of bread instead of 130 for soft wheat flour.

QUESTIONS

1. Give the history of cane sugar.
2. Where is it largely produced?
3. Give a brief account of the history of beet sugar.
4. What nations produce large quantities of beet sugar?
5. Where in the U. S. is cane sugar manufactured? Beet sugar?
6. Describe the principal operations in the manufacture of beet sugar.
7. How are the by-products used? State their value.
8. How extensive is flour manufacturing?
9. How is wheat handled previous to milling?
10. Describe the chief operations in flour-milling.

EXERCISES AND PROJECTS

1. Double a small strip of cotton cloth. Place 3 or 4 tablespoonfuls of flour on it. Now gather up the corners and knead under the tap. The starch grains wash out, leaving the gluten.
2. While Exercise 1 is being performed, let other members of the class repeat except that some use as much sugar as flour, others as much salt as flour, and another group just a little salt and a little sugar mixed with the flour. Each treatment should be done in duplicate. Compare results.
3. If convenient, and if agreeable to the miller, visit a flour mill. Let the miller show the machinery and explain the process.
4. Collect in small bottles the chief milling products. Label and preserve. A small box may be made as described at the end of Chapter 25.
5. If near a sugar factory and if the factory manager is willing, visit the factory. Let the guide show the machinery and explain the processes.

Note: Do not undertake these trips unless previously arranged.

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CHAPTER XLV

MILK AND ITS PRODUCTS

Milk is a special fluid secreted by the females of all animals that suckle their young. It is manufactured by special glands of the body located usually on the outside of the body wall, that is, between the body wall and the skin. Milk is an emulsion of fat in a watery solution of casein and various mineral salts. It is yellowish white, nontransparent, and has a slightly sweetish taste.

Milk Secretion. Milk is secreted in the individual cells which go to make up the udder, as the mammary glands of a cow are called. From each cell the milk is carried through small canals or ducts into larger ones which combine to unite on their way toward the opening in the teat, from which the milk is drawn.

Usually milk is not produced in the udder till about the time the female gives birth to young. At birth of the young the blood which went to nourish the unborn is turned to the udder, stimulating the cells to great activity, which results in the manufacture of milk.

Food, the ultimate source of milk, is taken into the body, digested, and absorbed by the blood which carries it to the udder whence the parts needed in the manufacture of milk are taken.

Milk Composition. Milk is composed of a great many different compounds, differing widely in composition and characteristics. These compounds may be classified into water and solids. The solids are composed of (a) fat; (b) casein, that part which curdles when milk sours; (c) albumin, which produces a thin skin or film over milk when heated; (d) milk sugar, the same in chemical composition as ordinary

sugar but less sweet; (e) ash, the mineral substance which remains after drying and burning milk. The following figures quoted from Babcock and Koenig by Wing show the average percentage and the variation of the constituents of milk:

Table X.—Percentage of Constituents of Milk.

	Average	*Maximum*	*Minimum*
Water	87.17	90.69	80.32
Fat	3.69	6.47	1.67
Casein	3.02	4.23	1.79
Albumin	.53	1.44	.25
Sugar	4.88	6.03	2.11
Ash	.71	1.21	.35

These figures show a possibility of some supposedly normal milk containing about three and one half times the amount of solids not fat contained in other milk and nearly four times the amount of fat. Mixed milk of a herd usually ranges between three and five and one half per cent fat.

Fat Percentages. The percentage of fat is a trifle higher during the first three or four weeks of the lactation period. After this time it remains fairly constant, except for irregular variations, till the seventh or eighth month. At this time the quantity of milk rapidly decreases and there is a tendency for the proportion of fat to increase.

The first milk may show even less than one per cent fat, while the last milk of the same milking may show as high as ten per cent fat. Contrary to popular belief, where cows are fed anything like sufficient rations, feed has little or no influence upon the percentage of fat in milk. The age of the cow seems to have little or no influence upon the richness of the milk in fat. The breed and individuality of the cow are the two chief factors governing the fat content of milk. The following figures give the relative fat content of various dairy breeds of cows, as reported by Eckles:

Jersey	5.14	Ayrshire	3.85
Guernsey	4.98	Holstein-Friesian	3.45

It is well known that within the same breed variations occur as great as the averages found between any two breeds.

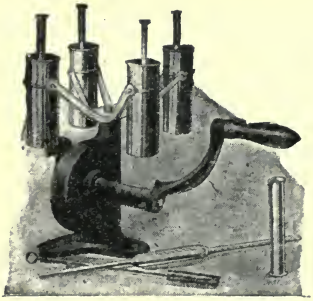


Figure 178.—A four-bottle hand-driven Babcock milk tester.

Jerseys are known giving as low as four per cent milk and others as high as six and one half per cent.

Variations in the *composition* of fat, that is, a hard or soft fat, a yellow or light fat, large or small fat globules, and flavor of fat, occur as a result of breed, individuality, feed, and period of lactation.

Milk Testing. On account of the variation in composition of milk and the ease with which it may be adulterated, it is necessary, as a protection to those purchasing milk, to have some means of determining the percentage of the various ingredients. Especially is this true of fat, as fat is so easily separated from the milk. For exact work well-known chemical methods are used. Many devices have been tried to determine quickly and conveniently the per cent of fat in milk. The one now almost universally used in the United States in commercial work and the only one which can be discussed here is the so-called Babcock test. With the necessary equipment and supplies at hand a Babcock test for fat can be made in about ten minutes. The test, if carefully made, is accurate to about one tenth of one per cent.

Babcock Test. The equipment needed for a Babcock test is:

1—A testing machine.

2—Test bottles.

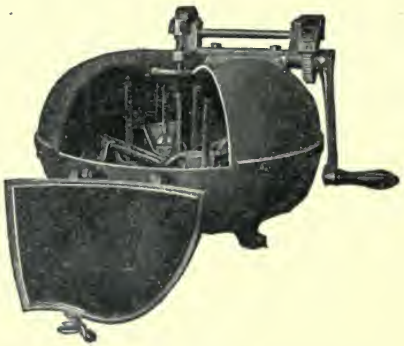


Figure 179.—Babcock milk tester, enclosed and driven by a steam turbine or by electricity.

Milk bottles graduated to 10% in 0.2 of a per cent.

Cream bottles graduated to 50% in 0.5 of a per cent.

Double-necked skim milk bottles graduated to 0.5% in hundredths of a per cent.

3—A milk pipette having a capacity of 17.6 c. c.

4—An acid measure having a capacity of 17.5 c. c.

5—A pair of dividers.

6—Concentrated commercial sulphuric acid.

The following directions apply to testing whole milk, skim milk and buttermilk. Cream is tested in the same way except that eighteen grams are *weighed* into the test bottle instead of being measured. In testing the richer creams (above 30 per cent) nine grams may be taken and the reading obtained doubled. In reading the test amyl alcohol or some other substance is placed on the fat column to destroy the meniscus. With the richer creams the reading may be taken from both extremes of the fat column and the reading decreased by one per cent.

Properly label the required number of test bottles. Thoroughly mix the sample of milk to be tested. A small round brush with stiff bristles is convenient for this purpose, as with this the cream which may have adhered to the sides of the sample jar can be removed and incorporated in the sample. As soon as the sample is well mixed fill the pipette exactly to the 17.6 c.c. mark and transfer this amount of milk into the proper test bottle. If the point of the pipette can be introduced down the neck of the test bottle so that the tip reaches the body of the bottle the milk can safely be introduced in this manner. Otherwise place the point of the pipette in the mouth of the bottle neck, hold the two at an angle to each other, and let the milk run slowly from the pipette. If a drop of the measured sample is lost another sample should be measured into a clean bottle. The last drop or two of milk may be removed from the pipette by gently blowing through it while its end is still in the bottle.

Figure 180.—Apparatus used in sampling and testing milk: A, Pipette; E, Milk thief for sampling; D, Dividers; B, Test bottle for milk; C, Acid measure.

Run all tests in duplicate. That is, measure out two test bottles of milk from each sample. When the test is completed the reading of the two bottles should not differ more than 0.2 per cent. If a greater difference than this is found, the test should be carefully repeated.

Fill the acid measure to the mark (17.5 c.c.) and carefully pour the acid into the bottle. Revolve the bottle slowly as the acid runs in so as to remove any milk or cream that may be clinging there. Mix the contents thoroughly by carefully shaking the bottle in a rotary motion. This should be continued till the curd has been completely dissolved as shown by the resulting mixture's assuming a brownish black color. The shaking should be gentle to avoid slopping into the neck of the bottle.

Put the bottles at once into the machine. Arrange them opposite each other to insure a proper balance and, therefore, smooth running of the machine. Whirl at the speed indicated on the tester which is usually from 80 to 100 turns per minute with hand machines. The first whirling should continue for five minutes. Stop the machine gradually and add hot water (about 150° F.) to the bottles with a clean pipette

till each is full to the bottom of the neck. Whirl again for two minutes, stop as before, add sufficient hot water to bring the fat column well within the graduations on the neck of the bottle, and whirl for one minute more. Care must be exercised in adding this last water not to overfill the neck and thus lose some of the fat.

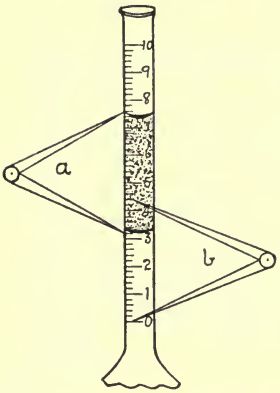


Figure 181.—Method of measuring the fat column (position a) and of reading the test (position b) in making a Babcock test.

When the test is completed remove the bottles from the machine and stand them in a vessel of warm water deep enough to cover them well up on the necks. The water should be kept at about 140°F.

The reading is best taken by means of dividers. Place one point of the dividers at the extreme bottom of the fat column and then spread them till the other point reaches the extreme top. (Fig. 181, "a.") With the dividers spread to exactly this degree, place one of their points on the zero mark. The mark up the neck where the other point falls gives the reading of the test. (Fig. 181, "b.")

Cream Separation. Cream is defined as "that part of milk into which a large portion of fat has been gathered." Cream is by far the most valuable part of milk, as it is from this that butter, the chief product, is made.

Separating the cream was first accomplished by the shallow-pan and the deep-setting systems. In the former, the milk was allowed to stand in shallow pans, and in the latter in deep vessels till the cream came to the surface. With these systems there is considerable loss of fat in the skim milk, amounting to from five to forty per cent of the total fat of average milk. This great loss of fat, together with the

long time and the vessels and space necessary for the satisfactory operation of these methods, makes them very unprofitable when working on a commercial basis.

Figure 182.—A cream separator

The Cream Separator. Most of the difficulties and losses of the old systems were overcome by the invention and perfection of the centrifugal machine separator. Separation of the cream in these machines is accomplished by the application of centrifugal force in a horizontal plane, in place of the force of gravity utilized in the shallow-pan or the deep-setting systems. There are a great many different makes of separators on the market, but they all operate on the same principle. The essential parts of all separators are the bowl, an inlet for whole milk, and an outlet for skim milk and one for cream, and some device for revolving the bowl at a high rate of speed.

Butter Making. Cream is usually soured before it is churned. It will sour if allowed to stand in an open vessel in a warm place. It is better to add an artificial starter or some buttermilk of good flavor saved from the last churning. Butter may be made from sweet cream, but more butter-fat is lost in the buttermilk than when the cream is ripened. Sweet cream butter also has a different flavor to which the market would have to become accustomed.

Churning is best done in a revolving churn in which the agitation is produced by the cream's falling upon itself and against the sides of the churn instead of by paddles or dashes.

The proper temperature for churning depends somewhat upon the nature of the cream. Between 56° and 65° F. will be found satisfactory under most conditions. The higher temperature is necessary in the winter. If the cream is the proper temperature, churning will occupy from twenty to forty-five minutes. When the cream "breaks" and the butter granules reach about the size of a pea, the churn should be stopped and the buttermilk drawn off.

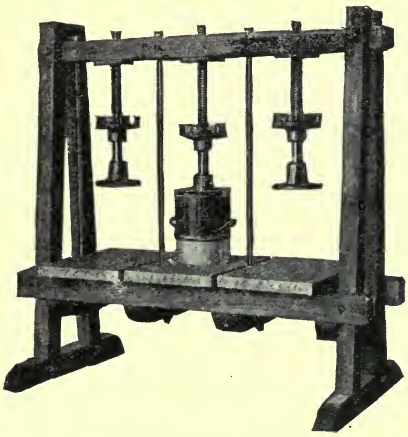


Figure 183.—Upright cheese press, showing one drop in place.

Washing. After the buttermilk is thoroughly drained off, clean water about the same temperature as the buttermilk should be added and then the churn given one or two turns. This water should then be drawn and more added. The second water should show no more than a slight milkiness when drawn. If it does, a third washing should be given.

Working. The amount of salt to add will vary to suit the taste of the consumer. Three quarters of an ounce to one ounce per pound is the usual amount. Butter is worked merely to insure an even distribution of the salt, expel the surplus water, and bring it into a compact form for handling. After these objects are accomplished, any further working will only injure the texture of the butter.

Moulding and Packing. Most butter for short shipment and immediate consumption is put in pound prints 4⅝x2½ x2⅜ inches, wrapped in parchment paper, and sometimes enclosed in cardboard cartons. This is by far the most

desirable way of marketing butter, as it reaches the consumer in a clean, unopened package. It is sometimes packed in ash tubs of various sizes.

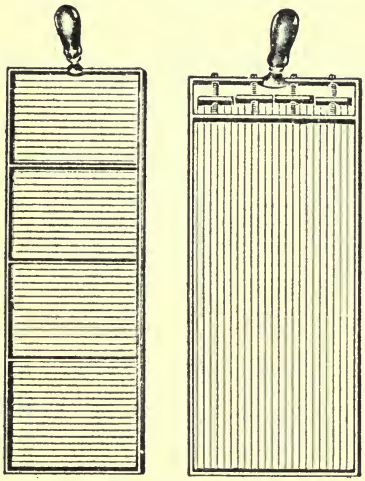
Cheese Making. In the process of cheese making most of the solids of milk are collected in the product. This is especially true of the casein and fat. A large part of the ash is also retained, though practically all the sugar is lost in the whey. Cheese consists of about equal parts of water, casein, and fat. The milk solids are collected by rendering the casein insoluble by coagulating or curdling it with rennet. As the casein sets it holds in its meshes the tiny globules of fat suspended in the milk.

There are a great many different kinds of cheese, the differences between them being produced chiefly by the process of ripening and by the kind of milk used. Only the ordinary, or cheddar, cheese can be discussed here. The processes involved in making this cheese may be grouped into eight periods.

Period I., Setting. The milk is gradually warmed up to 82°-86°F. and kept at this temperature until sufficient lactic acid has developed (0.19-0.21 per cent). When sour enough, two to three fluid ounces of rennet diluted in fifty times its volume of cold water are added for each thousand pounds of milk. This is quickly and uniformly stirred into the milk. After about thirty minutes the curd is firm enough for the next step.

Period II., Cutting. The curd is cut so the whey will run off more readily and completely. Cutting is best done by gangs of steel knives—one set of horizontal and one of vertical knives. See Fig. 184. The horizontal knives are run lengthwise of the vat, cutting the curd in thin layers. The vertical knives are then run both lengthwise and crosswise of the vat, leaving the curd cut in cubes about $\frac{3}{8}$ inch in diameter. As soon as cut the curd is gently agitated till the surfaces "heal" so the cubes will not adhere.

Period III., Heating. The cubes of curd are heated with constant stirring in the whey to make them contract and force out the water. Heating should be slow, the temperature rising not more than 2° in each five minutes. When a temperature of 94°-102°F. is reached it is held at this point till about 0.16-0.20 per cent acid is present in the whey and a test shows the curd to be ready for the next step.



Horizontal Perpendicular

Figure 184.—Curd knives used in cheese making.

Period IV., Cheddaring. This step causes more whey to escape and the curd to change from its original tough spongy condition to a smooth, elastic, fibrous mass. All the whey is allowed to drain from the vat and the cubes of curd mat together. This mass is cut in blocks about 8x8x12 inches and piled first two deep then later four and five deep with constant turning and restacking. The temperature is kept above 90°F.

Period V., Grinding. The blocks of curd are ground to cut them up into particles small enough to take salt readily and to be pressed into a solid mass. This process also helps to expel any disagreeable odors present. The curd is cut by running it through a curd mill of one kind or another.

Period VI., Salting. Addition of salt makes the curd drier and harder, and checks the development of lactic acid which has been going on up to this point. Salt is added chiefly, however, to improve the flavor of cheese. After the curd

is milled it is spread out thin at a temperature not below 90°F. and one and one half to three pounds of fairly coarse salt are added for each one hundred pounds of curd.

Period VII., Pressing. Spreading the curd for salting cools it off. When it reaches 78°-82°F. it should be put in the press. This removes any surplus water and causes the particles to

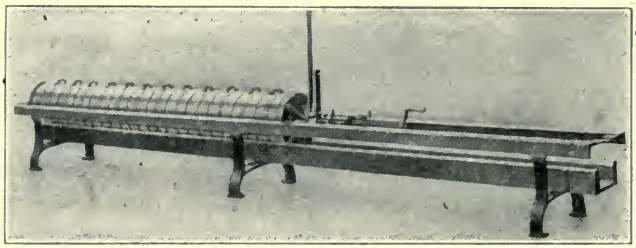


Figure 185.—Cheese press, showing a gang of hoops in place.

adhere into a uniform mass of convenient size and shape for handling. The pressure should be uniform, not great enough to expel the fat, and should be continued at least twenty-four hours.

After the cheese has been in the press forty-five to sixty minutes it should be taken out, turned, the bandage and caps straightened, and the whole surface sponged off with a cloth wrung from water as hot as the hand can stand.

Period VIII., Curing. Cheese is allowed to cure in order to develop the desired flavor and to become more digestible. Upon being taken out of the press the cheese is placed in a clean dark room having a uniform temperature of 65°-70°F. Each cheese should be turned over on the shelves every day during the early stages of curing. After five to seven days in the curing room the cheese is removed and dipped in a vat of molten paraffin. A thin film of this solidifies all over the cheese and prevents loss of moisture. In four to six weeks cheese is fairly well cured, though it continues to improve for three or four months.

QUESTIONS

1. What is milk?
2. What are the two chief factors which stimulate milk secretion?
3. Name six factors which influence the percentage of fat in milk and show the effect of each.
4. What makes possible the testing of milk by the Babcock method?
5. Why is it possible to separate cream from milk?
6. Upon what principle does the mechanical separation of cream depend?
7. What is meant by ripening cream? Of what value is it in butter making?
8. What constituents of milk are found in cheese which do not occur to any extent in butter?

EXERCISES AND PROJECTS

1. Determine the percentage of fat in milk, cream, skim milk and buttermilk. Use the Babcock testing outfit and samples. Follow directions given in the text, page 390.
2. Use a cream separator, milk, and pails. Weigh a batch of milk, sample and test, compute the amount of fat in the milk, then run it through the separator at the temperature and speed recommended for that particular machine. When the last of the milk has run in, flush out the bowl with a quart of warm water. Weigh and test the cream and skim milk and compute the amount of butter-fat recovered.
3. Test the effect of speed of the separator upon completeness of separation and upon the amount and thickness of the cream. Use a cream separator, milk, and pails. Warm a batch of milk (about three pailfuls) up to 80° F. Weigh out one pailful and run it through the machine at the recommended speed. Run another pailful through at 5 turns per minute faster than the recommended speed and the last pailful at 5 turns per minute slower than the recommended speed. Flush the bowl each time with one quart of warm water. Weigh and test the skim milk and cream from each separation and note any variations in amount or in fat content of the cream or skim milk which can be attributed to the different speeds.
4. Test the effect of temperature of the milk upon completeness of separation and upon the amount and the fat content of the skim milk and cream. Use a cream separator, milk and pails. Weigh, sample, and test three pails of milk. Warm one to 65° F.,

another to 80° F., and a third to 90° F. Run each through the separator at the speed recommended for the machine in use. Weigh, sample, and test the cream and skim milk from each. With the same speed, what effect had the change in temperature on the points mentioned in the object of this exercise?

Note: Because of the effect of heat on the body of the cream it is advisable to separate milk at the lowest temperature consistent with complete separation.

5. Test the keeping quality of milk under different conditions. Secure milk, test tubes plugged with cotton or small bottles, and a thermometer. Take the milk as soon as drawn and while still warm. Place samples of the fresh milk in three test tubes or bottles. Cover and leave one sample at the ordinary room temperature, another in running cold water and the third in ice water. Take the temperature of the water in both cases and record the temperature of the room. Note the length of time required for each sample to coagulate.

   What effect has cooling milk on its keeping qualities?

Note: If equipment is available, exercises in churning and cheese making can easily be outlined by the instructor.

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CHAPTER XLVI

DWELLING HOUSES.

The home scenes with which we are surrounded not only afford our enjoyment of their beauty as they appeal to us through sight, but go deeper and affect our habits and characters as well. While many estimable men and women have developed amid the crudest surroundings, yet it nevertheless remains true that beautiful and comfortable homes do tend to beget contentment of mind and refinement of spirit, and to satisfy a part of our nature as nothing else can.

Cost of House. In the planning of farm homes as well as in the barns, a proper balance should be maintained between the size of the farm and the amount invested in the buildings. The statistics for the United States show that the larger farms have better buildings but at a less proportionate cost. The farms of less than twenty acres have over one third of the capital invested in buildings and machinery. Those of over one hundred and seventy-five acres have less than one fifth in farm buildings. Money thus invested is not only unproductive but is a source of constant cost for repairs.

Planning the House. Farm homes, like city homes, are built under varied conditions. It is easy to build an expensive and convenient home if one has all of the money needed, but the difficult task, and the task which has to be solved by the majority of farmers as well as city folks, is to build a modern home of sufficient size with the means at hand. Here is where a good architect can be of great service; for, although you may have had experience in planning, yet after you have it all worked out, when bids are called for, you will generally find that the cost is double what you have to

spend. The collection of ideas and features relating to the house so that the structure, when finished, may be a home to suit the requirements is the part to be worked out by the owner, but the general style and material to be employed should be the work of the architect.

One author who is often quoted on this subject has said, "Few persons believe that they have no right to build until

Figure 186.—A pleasing outlook from the farm home.

professional help can be afforded; yet such a position would be well taken. Houses stand not for a month nor for a year, but for a generation. By them the thrift of a community is judged. By them the ideals and taste of a community are formed. He who deliberately builds an ugly house condemns himself as a poor citizen; while he who builds a beautiful house proves himself a good citizen; for his personal effort contributed to the public welfare."

A great deal of time and careful thought should be given to the planning. Other homes should be visited and the good points noted and copied. The best architects copy.

While in many respects the country home does not differ from the city residence, yet it is a mistake to copy exactly the houses of the city. The architectural possibilities of the country are much greater, and give the architect an opportunity to harmonize his design with the surroundings.

Location. On rather large farms it is often economy of time to place the house off the highway and about in the center of the farm. Where this is done, the house may be faced in the direction which affords the best view. The question of economy, however, is often outweighed by the fact that country life consists of too much seclusion and that it is necessary for proper development to be on the highway where one may keep in touch with his neighbors and with what is going on about him.

Exposure. The majority of persons prefer either a south or an east exposure. This seems to afford the best arrangement for sunshine.

Arrangement of Rooms. As mentioned above, a great deal of care and thought should be exercised in working out the floor plan, for it is very easy to get rooms entirely out of proportion for the use that is made of them; and these things are very difficult to remedy. You may see the rooms drawn on paper with dimensions and yet be very much misled unless you measure out each room and compare it with a room that you are now using. Doing so always prevents wrong impressions as to size.

The rooms which will be used most, the living and dining rooms, should be placed where they will get plenty of light and sunshine, and, if possible, an attractive outlook. Avoid placing stairways and halls on the side of the house, which arrangement would cut off the sunshine. A south and west exposure for the kitchen is entirely too warm. Any other corner is preferable.

Conveniences. A basement should be provided for a laundry, coal room and storage purposes. For country

Figure 187.—Farm conveniences; 1, pan cupboard; 2, dumb waiter; 3, dishwasher; 4, wood box attachment.

homes, a bathroom is more of a necessity than in the city. Water systems under pressure have been developed to the point where rural residences cannot afford to be without them. They provide running water for kitchen, bath, and laundry rooms.

Probably the two special things that should be remembered in planning a home for the farm, contrasted with one in the city, are the necessity for a small office, where the accounts are carefully kept, and the business transacted, and a washroom which should be placed in the rear of the house, and probably opening to the dining room.

What Rooms to Have. The advisability of a pantry is a disputed question, but it more properly belongs to the farm house than to the city residence. The kitchen should be smaller than those usually constructed for farm houses, probably about 12′ x 12′; but the dining room should be quite large so that in very cold weather it might save heating the living room.

There should be at least one large bedroom. The others may be smaller, and in number corresponding to the needs of the family. The arrangement of the windows to afford proper ventilation is important.

The living room has superseded the parlor, and seems to make available for economic use the space heretofore set apart for special occasions. The room should be large and cheerful, and, if within the means, a fireplace should be provided, since it adds wonderfully to the cheerfulness.

Lighting. Individual electric lighting systems which are very successful have been developed on low voltage for farm homes. The latest storage batteries allow some of the electricity to be stored up while the engine is being used for other purposes. In this way enough can be stored so that it is not necessary to have the engine running all the time the lights are on.

Wherever possible the farm home should be connected with company lines furnishing light. These demand less

capital and are usually better than small private plants. Proper attention to windows helps much in evenings and mornings.

Heating. While stoves will be used for sometime yet in most farm homes, it is just a matter of time till they will be replaced by the hot air furnace or the hot water system. Both systems are satisfactory, but the former costs only about one half as much as the latter. The hot water furnace requires a little less fuel.

QUESTIONS

1. How expensive ought farm houses to be?
2. State the chief considerations with regard to planning the house.
3. Where should the house be located?
4. Discuss room arrangement.
5. What conveniences are considered essential?
6. Give the main points in lighting.
7. What kinds of heating are worth considering?
8. Summarize the desirable qualities of a farm house.

EXERCISES AND PROJECTS

1. Visit two or three well-arranged houses. Note the arrangement of room and the conveniences.
2. List improvements that could be easily made in your own home.
3. Collect pictures.

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CHAPTER XLVII

FARM BUILDINGS

Farm buildings, as a rule, have received very little thought in the past as regards their proper location, construction, and the convenience that might be afforded by a little more careful planning. L. H. Bailey says: "The buildings surely express the man; you know something of his type of mind when you see his house and barns and sheds. Awkward, straggling, unrelated buildings indicate loose and purposeless ways of thinking. Good farming follows only good mental processes; these processes work themselves out in the crop schemes, the market business, the buildings. Rarely do you see efficient and convenient buildings without seeing also a good farmer; and efficient and convenient buildings are almost necessarily tasteful buildings."

Layout. Not only the buildings themselves but the disposition and arrangement of them have relation to their efficiency and tastefulness. It is unquestionably true that there has been a tendency to scatter the buildings, particularly the barns, far beyond the point of efficiency and convenience. It would be interesting to make a computation as to how much time and labor are wasted each year in doing chores in separated buildings. Management concentrates activities.

Some of the principles governing their proper location are as follows: As a rule, the buildings should be placed on high ground; but, if this is not available, they should be placed on soil that will drain well. They should occupy about the center of the farm, as near as possible to save time in getting to and from work. Should there be a piece of rocky land or waste land that will not grow a crop, filling the above requirements, such should be chosen in the interest of economy; and usually such can be found.

The outbuildings should be near enough to the house that accident which might occur at night or while the men are away from the barns may be detected readily. Many accidents which might have resulted seriously have been prevented in this way.

Site. A southwest slope is desirable; the buildings should be placed on the side of the farm nearest the town; they should be not less than two hundred feet from the highway; and the house should be not less than two hundred feet from the barn and not in the leeward of the prevailing winds. Corrals should be on the farther side of the barn.

Farmsteads are laid out by two plans: (1) the one involving separate barns for the cows and horses, known as the *distributed system*, and (2) the *concentrated system*, where both are housed under the same roof. There are advantages and disadvantages in both. The former usually requires the greater outlay, and hence is less often used. The latter system is the one common in the West.

Under the concentrated system the farmer has a more imposing structure. There is a saving in labor, but in case of fire there is usually a greater loss.

Barns. In this region, the barns are usually constructed to accommodate horses and cows. Where this is done a substantial gate should separate the two sections.

The stock may be faced in or out, there being advantages and disadvantages to both methods. Stalls placed so that the animals face in are more convenient in feeding because hay thrown into an alley is near the heads of the animals. Ventilation is more effective. In facing out, the advantages are: (1) ease in removing the litter, (2) ease in milking, and (3) ease in handling the cows. Facing in is probably more often used.

A good, serviceable barn of this type is one built with a central position for hay, and a lean-to on either side. One side is thus used for cows and the other for horses.

In cattle barns the height of ceiling should be not to exceed nine feet. Stalls should be three feet six inches wide, mangers two feet four inches wide, gutters sixteen inches wide and six inches deep and should lead to manure pit in order that the liquid portions of the manure may be saved.

Figure 188.—A dairy cow and horse barn with double silo.

Litter and feed carriers are a great convenience, allowing the feed to be carried easily to each stall, and the litter to be removed just as conveniently.

Barn Fixtures. In the stalls of the modern dairy barn, wood is being rapidly replaced by concrete, iron netting, and piping, because they are much more sanitary. The up-to-date stanchion now proves satisfactory in every way. It is used entirely in the modern barn. Concrete floors for the cow barns are satisfactory and sanitary, but should be given a rough finish to prevent the animals from slipping. They are regarded by some as cold in winter. This defect can be relieved by using a temporary wooden floor in winter which can be removed during the summer and while cleaning in winter.

In the horse barn concrete is not so satisfactory, but is often used in the back part of the stall with clay under the front feet. Clay or wood floors are better.

Each horse requires from seven hundred to one thousand cubic feet of space. This requires a width of twenty feet for a single row of stalls and thirty feet for a double row. Ceilings should be eight feet in the clear. Single stalls are four feet six inches wide, and double stalls, eight feet. A very shallow gutter of about two inches is useful.

Hog Houses. These are constructed in two ways: (1) the individual or colony house, and (2) the concentrated house or swine barn. The advantage of the colony house is less danger of spreading disease. If the location becomes unsanitary, the house may be moved to better location. The house can be put at the opposite end of lot from the trough, thus affording the pigs more exercise and keeping them free from disturbance at farrowing time.

The advantages of the concentrated type are (1) that it has a better appearance; (2) that it saves time in handling; (3) that it is more easily heated in northern climates for early litters; (4) and that it saves fencing.

The individual house is usually made nowadays of the A type, and of varied construction; the customary dimensions are eight square feet at the bottom and six feet eight inches in height, which size requires an eight-foot rafter.

Poultry Houses. Successful poultrymen agree that a knowledge and appreciation of the principles involved in the proper housing of poultry are necessary to success along this line.

(1) The first point to consider is *dry quarters.* If an earth floor is used, it should be well-drained and kept dry; if concrete is used, gravel beneath or a layer of tarred felt through the middle will prevent dampness. (2) *Ventilation* is also vital. Fowls can stand reasonably cold air better than impure air, even though it be warm; hence, we have changed our choice from the closed heated house to one with open front. It is necessary in these houses to have the back

constructed of matched lumber to prevent draughts. (3) The house should face the south, thus insuring plenty of sunlight and warmth. Sunlight is also a disinfectant and germicide. (4) It should be made convenient. Care should be exercised in this respect; doors, fixtures, nests, and drop boards should be arranged in such a way that they can be easily reached and kept clean. The building should be located conveniently to the house. (5) To avoid danger from rats and mice the building should not be placed near a granary. Nests, perches, and interior finish should be as smooth and free from cracks as possible so as not to harbor mites. (6) The cost of the house should not exceed $1.25 a fowl and may be as low as $.60.

As in the case of hogs, two systems of housing are used: (1) the colony type, or small movable house, and (2) the permanent type of large house. The advantages and disadvantages of each are similar to those for housing swine.

Silos. While the silo has not been used to any considerable extent in the West as yet, the increased interest manifest during the last year or two and the number of silos that have been built justify a consideration of them. The materials used in this section are wood stave, concrete block, and concrete in continuous walls, known as monolithic concrete. These types have all been tried out and all give reasonable satisfaction. The old idea, that the acids of the silage would affect the concrete and in time cause it to crumble, has been entirely overthrown by more recent experience and it is conceded that the concrete silo is unquestionably a success. Wood silos are slightly cheaper than cement, costing about $2.40 for each ton of storage capacity while the monolithic concrete costs approximately $2.60 to $3.00 and block silos, on the average, about $.70 per ton more than the monolithic.

The diameter of the silo is determined by the number of cows to be fed, as two to three inches must be used from

the top each day to prevent spoiling. The height is determined by the number of cows and the number of days they are to be fed each season.

Table XI.—Diameters of Silos

Number of Dairy Cows	Feed for 180 days	Feed for 240 days	Diameter of Silo
8	29 tons	40 tons	8 feet
10	36 "	48 "	10 "
15	54 "	72 "	10 "
20	72 "	96 "	12 "
25	90 "	120 "	14 "
30	108 "	144 "	16 "
35	126 "	168 "	16 "
40	144 "	192 "	18 "
45	162 "	216 "	18 "
50	180 "	240 "	20 "
60	216 "	288 "	22 "
70	252 "	336 "	22 "
80	288 "	384 "	22 "
90	324 "	432 "	22 "
100	360 "	480 "	22 "

QUESTIONS

1. Can a man be judged by his farm buildings?
2. Describe a good layout.
3. How near should barns be to the house?
4. What is considered a good site for the farm buildings?
5. What are the things to keep in mind in planning the barn?
6. Discuss floors, stanchions, stalls, and drains for the barn.
7. How should hog houses be constructed?
8. Give the essentials of good poultry houses.
9. How much do silos cost?
10. What determines their size?
11. Give sizes for various quantities of feed.

EXERCISES AND PROJECTS

1. Visit barns. Decide what kind is best. Draw rough plans.
2. Collect pictures.

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CHAPTER XLVIII

IMPROVEMENT OF PLANTS AND ANIMALS

In a given region all the individuals of a species of wild animals or plants are very much alike, while in that same region the individuals of the domesticated animals and plants are variable. Compare, for instance, the wild grouse with the domestic hen, the deer or buffalo with domestic cattle, the wild wheat grass and cultivated wheats. The wild species are found to be very constant in every case, while the domesticated species are divided into breeds or varieties, and even these are variable among themselves. The reason is not hard to find. The wild species have become fixed and definite within small limits through the action of nature's laws, but the domestic species have been taken from under the action of these laws and subjected to man's wishes.

Nature through countless generations has been producing an excess of individuals and then selecting from among this throng those best adapted to the conditions of life in that particular region. On deserts, for example, most of the plants are white or light-colored; their leaves are small, the plant thorny or hairy or both; and other modifications appear which enable them to survive in hot, dry situations. If any offspring of these appear with variations not fitted for desert conditions, they die and leave the races fixed and adapted as we see them to-day.

Nature constantly eliminates the weak, the unfortunate, and the unfit, by this means keeping the race vigorous, stable, and fitted to its surroundings. If we wish to maintain our domestic animals and plants even at their present standard, we must follow nature's methods. If we wish to

improve them rapidly, we must be even more rigorous and systematic in our selection than nature has been.

Mendel's Law. Certain characters in plants and animals have been found to be transmitted according to a definite law called Mendel's law, after its discoverer. This law can best be illustrated by a simple example.

If gray mice and white mice are crossed, the offspring will all be gray. If now these hybrid offspring are bred together they will have both gray and white progeny in the proportion of three gray to one white. If these latter white mice are bred together they will have only white progeny the same as any other pure white mice. If the gray mice are bred together one will be found to be pure gray and two will be found to be hybrids like their parents and will give one fourth white progeny. Out of every four second-generation progeny, then, on the average, one will be pure white like one parent, and one pure gray like the other parent, and two will be hybrids. The gray color is called dominant, because it dominates over the white in the hybrids. The white is called recessive, because it is hidden in the hybrids.

There are many color and structural characters in plants and animals that never mix or blend but behave in the same way in which white and gray do in mice. The white face of the Hereford, chestnut color in horses, and the polled conditions in cattle are common examples of Mendelian dominants. In interpreting the results obtained in breeding, this law must be kept in mind, for it is in action nearly everywhere. Surprisingly little blending occurs.

Table XII.—Illustration of Mendel's Law.

Parents (pure)	1st Generation (all hybrids)		2nd Generation	
Gray	Gray	3	1	Gray (pure)
	Gray		2	Gray (hybrid)
	Gray			Gray (hybrid)
White	Gray	1		White (pure)

The Ideal Sought. The most successful breeders have been the ones who have had the most definite ideal or "type" in mind, and who have never been lured away from their purpose by something that apparently offered more immediate success.

The smaller the number of characters desired in the "type" the more easily it can be attained. The American trotter has been bred for but one qualification—speed. There has been no restriction in size, color, style, disposition, or conformation. As a result, wonderful success has been attained in developing the one quality—speed. Along with this they have developed or retained vigor and endurance, because these qualities were necessary to the one end sought.

Figure 189.—A plant-breeding plat.

The dairy breeds have not improved as rapidly in production, because they have had to meet color requirements, pedigree requirements, and the show ring standards, as well as production tests. Poultry breeding for production has been even more handicapped by the standards, because they are the creation of the fancier and not of the utility breeder. It is a significant fact that nearly all winners in egg-laying contests are white fowls, not that white strains are really any better, but that a higher percentage of white chickens than of any other color reproduce true to color. Thus we have a greater number from which to select egg producers.

Basis of Selection. Much selection, because it lacked definite basis, has been of little value. For example, the

greater part of the seed selection practiced by the farmer has for its ultimate purpose the maintenance or increase of the acre yield, and selection should, of course, be on that basis. Instead, then, of selecting the largest and most perfect ear of corn which probably was the only one on a stalk standing alone, the somewhat smaller ears from a hill in which there were two or three stalks bearing from four to six good-sized ears should have been selected. Even better would have been the selection of the best ear from the heaviest-yielding stalk in a proper-sized and heavy-yielding hill. If all the field had been like the first hill, the yield would have been very low. The first stalk probably lacked in productive power or else there would have been two or three ears instead of the one. The second stalk has demonstrated its productive qualities in competition with other vigorous rivals in the hill and is more likely to transmit them.

In the same way not the big potato but those from the hill which has the largest quantity of marketable tubers should be selected. Bin selection of most seeds is of little value. Selecting by fanning so as to obtain only the biggest kernels of wheat for seed would probably decrease the yield. These kernels probably grew in short heads or from stools that had only one or two heads.

Too many dairy cows have been selected for show ring points or because they gave a large amount of milk, without knowing anything about the fat content. A cow that continues to give good results for a number of years is better than one that gives a good yield one year and then drops down again. In poultry breeding it has been learned that the exceptional producer of the first year rarely holds out, but that the largest number of eggs and the most vigorous strains come from more moderate producers.

Hereditary Power. The most rapid and definite improvement of a given strain, however, requires the use of still another principle in selection. The potato that goes into

the ground decays and disappears. It is only through its progeny that we are repaid. The stallion, no matter how perfect, is of no value to a community except as measured by the colts he leaves. Therefore, in judging a plant or an animal, breeders should look not only for good qualities in the individual, but also for assurance that those qualities will be transmitted. Two animals of the same individual merit may differ greatly in "hereditary power"—the power to transmit.

For example, each of two cows, with the same butter-fat production, had four daughters with butter-fat production as follows:

Cow A 400 lbs.	(1) 600 (2) 300 (3) 250 (4) 150	Average 325 lbs.
Cow B 400 lbs.	(1) 500 (2) 450 (3) 400 (4) 350	Average 425 lbs.

The value of these two cows as producers was exactly alike. As founders of a herd, cow B's daughters produced 400 lbs. more of butter-fat a year than the daughters of cow A. This difference would amount to at least $100 each year in the first generation. The average of the next generation very likely would be close to the average of the race. In that case, cow B's grandaughters would continue to average close to 100 lbs. more of butter-fat than the granddaughters of cow A.

Transmission of Characters. In selecting, the poorest in any strain should always be discarded. Following that, the *average of the race* should have as great a weight as the individual qualities. In the above example, the second daughter of cow B would probably be more valuable as a breeder than the first daughter of cow A. In practice, the record of every individual in the strain, whether of ancestry, of relative, or of progeny, is of value in determining

the hereditary power. When this principle is thoroughly understood the largest prizes will not be offered for the exceptional individual, but for the individual that can show the largest number of exceptional progeny.

Probably the most common mistake made in breeding lines by those who are not special students of heredity is in expecting the individual of exceptional merit to produce offspring equaling its record. This result will rarely occur. This individual was the extreme variation in a particular line from the average of its race, and although that variation will tend to be transmitted, the tendency to swing back nearer the average will be even stronger. If that animal is the best in one hundred, the chance that its record will be equaled by any of its progeny is, under ordinary conditions, only a little more than two in a hundred, and the chance that an offspring will exceed its record, not more than two in a thousand.

How Improvement Comes. On the other hand, the chances are that some one or more of the next generation will equal or exceed this record. If there were one hundred animals in the original list, about fifty of them would be above "average" and fifty below. The majority of the higher records of the next generation will come from the offspring of the fifty best animals. From which one the highest will come cannot be told; but, even granting that the chance of its coming from the best parent is twice as great as from any other one of those above the average, still the chance is only about two in fifty, which is probably above the truth.

At first glance, one might conclude from the preceding principle that there is no value in pure-bred animals; but, instead, it shows why there is. It is the *average* of the race that determines largely what the progeny will be, and the average of the pure-bred is much higher than that of the scrub. In the same way the average of the progeny of an

exceptional individual will be much above the average of the race, and if two exceptional pure-bred individuals are bred together then the average of the progeny may be expected to be still higher.

Practical Applications. The methods used in improving plants and animals differ widely owing to the fact that with animals it is possible to select the male as well as the female parent, whereas in most plants this is difficult. Then too, in

Figure 190.—Hen and the eggs laid for six years, first year at left, others in order.

most animals, reproduction is comparatively slow and it is necessary to keep nearly all females, but in plants the great majority can be rejected and only the best retained.

Rapid progress can be made in improving the average of the horses or cattle of a community with comparatively small expense by the introduction of one or two pure-bred males of the right hereditary power. One such male in a community should have between fifty and one hundred *grade* female progeny in five years. In ten years five hundred to one thousand would carry his blood. The initial cost of an exceptional animal would amount to very little when divided among so many. By continuing to bring in pure-bred males of the same type the standard can be raised from year to year. The *grade* males from this breeding should never be used, as they are hybrids and cannot be depended upon to produce progeny like themselves.

In chickens and pigs, which reproduce more rapidly, it is usually best to start with a few pure-bred individuals.

In selecting males, as far as possible take only those that have been tested; and in this respect judge them largely by their progeny.

In the improvement of a grain crop like wheat, a number of the best stools in the field should be selected and each one harvested separately. These should be sown in rows of uniform length side by side, and a few of the best rows, after the selections have been made, can be used to plant a small plot from which pure seed may be obtained or further selection made. A pure strain will germinate and ripen alike, and is more valuable for milling purposes than the too common mixtures. By long continued selection, even these pure strains may be further improved.

QUESTIONS

1. Why are domesticated animals and plants more variable than wild ones?
2. What is Mendel's Law?
3. Why are the first generation progeny alike?
4. Name characters in plants and animals that are dominant.
5. What is meant by a "type"?
6. Why has America produced the trotting horse but not a drafter?
7. What has retarded the breeding of a "dairy type," an "egg-laying type"?
8. What is hereditary power? How is it measured?
9. Can one "select" seed potatoes from a bin?
10. How should one proceed to select in order to improve a herd of dairy cows?
11. Are the progeny of an exceptional individual likely to be as good as that individual?
12. Why are pure-bred animals of more value than grades or scrubs?
13. How should the animals of a community be improved?
14. How can a farmer improve his wheat crop?

EXERCISES AND PROJECTS

1. Select two areas—one with rich, moist soil in the shade, another on a dry barren hillside. Note the difference in the plants, kinds, height, breadth of leaves, strength of stems, color.

2. Note the number of different breeds of dogs as compared with the wolf.
3. Note the number of kinds of tame pigeons compared with the Mourning Dove, chickens compared with the grouse. Get some tame mice or guinea pigs of different colors and cross them and note the result in the first generation,—the second.
4. Study milk records of cows in cow-testing associations adjacent. Note the comparative production of related animals—daughters of one sire.
5. What would the yield of an acre of corn be if each hill had one stalk with one good ear—three stalks with two average ears each?
6. Make a study of variation in corn hills, in stools of wheat, and in potato hills.

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CHAPTER XLIX

LIGHT AND THE WATER SUPPLY

Wherever ordinary care is taken to promote proper sanitation, the water supply must be guarded judiciously, because it gathers impurities rather easily. Likewise, light is a serious problem in all buildings, because defects are likely to be unnoticed. Neglect of either light or water is fraught with so much danger as to deserve constant attention: they are of prime importance to best health.

LIGHT

In any building designed to be occupied by human beings, adequate provision should be made for the entrance of light and air. One of the most valuable things in the home, from a sanitary standpoint, is ample window space. In the building of a house and in the placing of the windows, advantage should be taken of the southern sun in order to reach by direct sunlight as much of the floor and wall space as possible. Light, in addition to its value as a sanitary agent, has a marked physiological influence upon those who live in the house. Poorly lighted rooms have a decidedly depressing effect, physically, upon the housewife especially, who spends much time in the house.

The eye-strain which follows reading in poorly lighted rooms tends to encourage undesirable, physiological reactions such as defective digestion, circulation, and excretion. Irritability is increased by working in rooms poorly lighted. Although shade trees and shrubs have great value in beautifying the home and in protecting us from the extreme heat of the sun, yet these should be so arranged around the house that they do not interfere with the entrance of light.

Bacteria do not thrive in the presence of diffused light and may be killed by the continuous application of sunlight. It is obvious, therefore, that the cleanliness of a room, from the standpoint of bacteria, will vary directly in proportion to the amount of light, and especially sunlight, admitted. When it is considered that many disease germs, such as the germs causing tuberculosis (or consumption, as the lung form of this disease is called) and diphtheria are deposited on the floor with the spittle and various other excreta of the body, any agent that will kill these is welcome.

Artificial Light. The Rocky Mountain States are especially fortunate in that they comprise an area where electricity is generated in large quantities and they consequently have available for lighting, as well as for various other purposes, electricity at reasonable rates. This facility eliminates, in large measure, the unsatisfactory and dangerous gasoline lamp, the candle, and the gas devices so common in many other localities.

Civilization demands that the working day extend far beyond the "sun to sun" of older times. Much of the social family life is encompassed in the period following the day's labor and preceding retirement at from nine to eleven o'clock. In making this period cheerful electricity has contributed a large share.

There are a few general principles which should be followed in the lighting of homes. Contrasts of extreme light and darkness should be avoided; the light should be diffused as evenly as possible throughout the rooms; bright glares should be avoided. For this purpose the reflected or "invisible" light has come very recently into quite general use not only in public places but in homes. The globes are held in an opaque cup and the light is reflected against the ceiling or wall. A frosting over the globe aids materially in satisfactorily diffusing the light and avoiding the eye-strain of a too concentrated light.

WATER

Water is necessary for all animal life; the human body is composed of about sixty-five per cent of water, which is continually being lost by evaporation and through the various excreta, and which must, therefore, be replaced. Water readily dissolves many substances, and is consequently seldom found absolutely pure. Many of the substances in solution are, however, harmless.

Hard and Soft Water. The water usually found in our mountain springs is called *hard* water, because it contains calcium salts in solution. It is usually characterized by its inability to readily form a lather with soap. Many spring waters are rich in carbon dioxide, a gas which arises from decaying vegetation of all kinds and which readily dissolves in water. The presence of this carbon dioxide makes it possible for the water to hold in solution large quantities of the carbonate of lime, limestone. Water on the surface, such as rain water, has had no opportunity to dissolve the mineral ingredients of soil and is, consequently, *soft*. Distilled water is also devoid of minerals. For drinking purposes water should not be very hard, as large quantities of some minerals irritate the stomach and intestines.

Bacteria in Water. Minute plants and animals get into practically all drinking water. There may be millions in each cubic centimeter, if the water is badly contaminated. Usually they are harmless; but there may be the germs of such diseases as typhoid fever, dysentery, and cholera. They get into the water by means of sewage, usually from persons suffering from the disease. When the germs are introduced into the bodies of susceptible individuals they multiply rapidly, causing disease and often death.

Sources of Water. The well is a common source of water, especially in rural communities. This is a satisfactory source provided no water finds its way into the well from surface drainage which does not pass through at least

fifteen feet of earth, which will filter out practically all the undesirable germs. Fifteen feet is usually regarded as a minimum depth for a sanitary well, as a less depth affords too easy access to surface drainage; but even this depth may not be enough to prevent surface pollution in loose porous soil. A bored or driven well is much safer than an open one on account of the greater difficulty of the entrance of surface drainage.

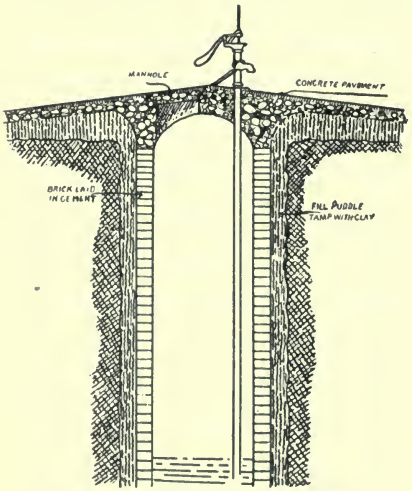

Figure 191.—Proper casing for a well.

To be protected amply, a well should be lined as far as the water level with cement, stone, or similar material. The top should be at least six inches above the surface of the ground, and the sides should slope a sufficient distance from the opening to prevent washings and dirt from entering. In porous soil it is well to fill in the space between the brick and soil with clay.

Artesian water is very frequently used in Utah and the other intermountain states. Such water is usually free from contamination, but is generally hard.

The water from reservoirs and brooks is liable to contamination and should be used for drinking purposes with extreme caution, even where the country is sparsely settled. Where water of this nature is used in any considerable quantities for drinking purposes careful investigation should be made of the source of the water in order to determine whether, during its course, it is open to contamination, which,

if discovered, should be abolished. It is a matter of history that a great many epidemics, of typhoid fever especially, are traceable to poorly protected water supplies. In many instances the diseases of one person have been transmitted to lower districts through the agency of water. Water-borne outbreaks of disease usually accrue in the spring or early fall due to the fact that rains and melting snow wash into the supply a sewage which contains disease-producing organisms. Hence it is especially necessary that water be guarded during these seasons.

Purification of Water. Spring water is usually safe if it is filtered directly through a sandy hill, provided, in all cases, that after coming to the surface it remains uncontaminated.

On a large scale, water is purified by sand filteration. Such a filter is built at slight cost and consists usually of a settling bed, which varies in size according to the amount of water required, in which the water obtained from a river or elsewhere is allowed to stand and drain off from the top. This method removes those germs which settle to the bottom of the reservoir. The water which is drained off the top is conducted into a second bed for further purification. The second reservoir is usually a pit of earth in the bottom of which open pipes are laid, these draining into a common pipe. The pipes are covered with one or two feet of coarse gravel upon which is placed a second coating of sand from three to six feet thick. As the water drains through this sand and gravel bed, between ninety-five and ninety-nine per cent of the organisms are removed.

The purification process consists of the action of harmless organisms in the soil, which, by forming a thin film upon the sand grains, have the power to destroy organic substances, including disease germs, in the water as these substances pass through during filtration. Such filters tend to clog and become very slow in action unless occasionally

cleaned. The large number of filters designed to be attached to water faucets are practically useless. Filtering through porcelain or infusorial earth is effective but too slow for ordinary uses. The most satisfactory method in the case of especially dangerous water is boiling. The palatability of boiled water may be restored by shaking it up with air after boiling.

QUESTIONS

1. Why do light and the water supply deserve special attention?
2. Give the essentials of homes well-lighted by day and by night.
3. How does poor light cause eye-strain?
4. Explain what is meant by hard and soft water.
5. In what ways does the source of water affect its purity?
6. Discuss purification of water.

EXERCISES AND PROJECTS

1. Examine several kinds of lighting systems if they are available.
2. Investigate the source, the works, and plan of your water system.
3. Examine homes and schoolroom to see if they are properly lighted.
4. Collect pictures.

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CHAPTER L

GOOD ROADS AND THE TELEPHONE

Railroads, steamships, and telegraphs have done much to diminish the importance of transcontinental or interstate wagon roads. Formerly, a man must journey to town to talk over a matter with his neighbor or merchant; now he can transact much of his everyday business by telephone, saving time and travel. Produce, however, must go by wagons at least to the railroad station or to the country store. Whatever railroads or ships carry, wagons must carry first and afterwards, though, sometimes, only for a short distance, but too often on poor roads.

ROADS

History. Roads seem to date back as far as any part of our history. It would seem that roads have been in existence ever since wheeled vehicles have been used. The Bible states that when Pharaoh's army was pursuing the Israelites they had six hundred picked chariots besides many others. There was a road when King Cheops built the great pyramids, since the stones had to be transferred from quarry to pyramid. Recently the remains of this road were found in the form of a great stone highway. Probably the first stone bridge known in history was built at Babylon. Babylonians understood also the use of asphalt, for in the great wall built around the city of Babylon the stones were cemented together with asphalt instead of mortar such as is used nowadays.

The most important roads of history are those of the Romans. Even now the road writers make mention of the wonderful road built by Appius Claudius in 312 B. C. This was constructed of stone blocks with masonry. If built to-day, even with all our modern machinery, it is estimated that it would cost from fifty thousand to two hundred thou-

sand dollars a mile. Broken stone roads were used in France as early as the seventh century. The building of roads in that locality was primarily for the rapid transmitting of armies. After the fall of the Roman Empire road engineering suffered a relapse in Europe, and the road building which comes to us as most important is the construction work that was done in England.

Traction Factors. The object of making a road is that we may get a load or vehicle with greater ease from one section to another. The resistance from the traction in traveling may be divided into four kinds: (1) axle friction, (2) rolling resistance due to irregularity in the ground, (3) grade resistance, and (4) the air resistance which is made greater or less, due to the direction of the air current as compared with the travel. The axle resistance is about the same on all vehicles and on all roads. The air resistance is uncontrollable. So, only two of these four need to be considered.

The force necessary to pull a loaded wagon along a road when the wagon is included in the load varies with the type of road, but on level ground is about as follows: on an asphalt road from 30 to 70 pounds a ton; on a brick pavement from 15 to 40 pounds; on earth roads, under ordinary conditions, from 50 to 200 pounds; on gravel from 50 to 100 pounds per ton; on macadam roads 20 to 100 pounds; on sand, in ordinary conditions, from 100 to 300 pounds; on steel wheel rut 15 to 20 pounds. Considerable extra draft is required by irregularities such as culvert edges or ruts.

When a load is drawn up a hill the extra work done in pulling the load along this road is equivalent to lifting the load a distance equal to that from the foot of the hill to the top of the hill. If the road has five per cent grade, the load will be raised five feet in traveling one hundred feet. On an ordinary earth road the tractive force is one hundred pounds per ton. Pulling a ton up a grade of five feet in one hundred feet is equivalent to doing ten thousand foot-

pounds of work. The work is distributed over a hundred feet. Dividing by one hundred, the extra pull, which is continuous, is found to be one hundred pounds a ton. If the force necessary to draw a load along the level is one hundred pounds, then to this must be added the additional amount of the tractive force necessary to pull the load up the five per cent grade on the same type of road, making two hundred pounds per ton.

What a Horse Can Do. Recent experiments have shown that if a horse is to be worked continuously, as in plowing or pulling a mowing machine, he can be worked against a tractive force equal to about one tenth of his weight. For very short periods the horse may be made to work against even up to one half of his weight and for a fraction of a second up to three fourths of his weight. But as soon as the time is extended at which he is driven at more than one tenth of his weight he will begin to perspire and fret against the load. Actual experience has shown that a good average horse can draw about 3,500 pounds on a good road. When grade is added to this, we find that a team of 1,500-pound horses should be able to pull as follows:

Per cent grade		*Pounds*
1	About	6,000
2	"	5,000
3	Little less than	4,000
4	About	3,380
5	"	2,950
10	"	1,972
15	"	720
20	Only about	300

From this can be seen the necessity of making better grades and smoother roads in most country districts.

Types of Roads. The types of road regularly constructed in our locality include earth roads, gravel roads, macadam roads, sand-clay roads, and concrete pavements.

Earth roads vary greatly and include those made by merely traveling on them, and those graded, drained, and

smoothed. In the construction of an earth road there are two essentials,—one to keep the water off or out of the road, and the other to keep the road smooth. The drainage consists in two principles: (1) drain away the water which renders the road soft and boggy, and (2) prevent the water which falls upon the road from remaining there and making the road muddy. The first must be accomplished by drain ditches; the second by making the road of such a shape that water will not stay on it. A cross-section of an earth road will vary some with the character of the material used.

In the construction of earth roads the grade and shaping of the grade can be largely done with a grader. The traction engine is more desirable than horses, because it packs the road and is more steady in the pull. Earth roads in thickly populated districts should probably not be built wider than 30 feet; in more sparsely settled districts 20 feet will be sufficient. Every time a load is drawn over the earth road when it is moist there is a tendency for it to rut. As soon as the material in the road is in a condition to be worked, a drag should be pulled over it first on one side and then on the other, throwing the piles of earth which accumulate on the outside of the wagon track into the rut. That part of the earth road which received the travel will be completely packed and the material under the wheel will become so firm that wagons will not cut in. If earth roads are to remain in good form, the ruts should be filled by dragging after each rainstorm during the summer.

Gravel roads differ only from earth roads in the usual method of laying from six inches to a foot of gravel on top of the road after grading has been done. Gravel should not be put on an earth road until properly shaped, if shaping is to be done, or it will always result in the loss of much gravel that has been hauled. The gravel should be carefully spread before being traveled on and not merely dumped in the road. If it is not carefully spread and worked over, the

road will be hummocky and these irregularities are hard to move. No large stones should be allowed to remain in the gravel close to the surface of the road. It is found a good thing to harrow the road with a steel harrow after the gravel has been hauled. The harrow will bring to the surface large stones which will have to be removed sooner or later. These stones may be placed in the bottom of the ungraveled portion. It is well to follow the macadam rule, that no stone should be left in the top dressing of a gravel road which cannot be put in the mouth. Gravel roads can be dragged in the same way as earth roads and should receive about the same treatment, if they are to be kept smooth. If ruts occur in the gravel road, the ruts should be filled with good gravel and no more put in than enough to fill up the hole. If the weather is dry, a pail of water poured on the gravel will help materially in cementing it into place.

Macadam roads are used in the East but they do not seem to be a success in arid sections. They ravel to pieces if allowed to become dry. Cost and maintenance are both beyond the means of the sparsely settled sections.

Concrete Roads. Of the many types of high-class roads the one which is probably giving the greatest satisfaction is the concrete road, made of Portland cement and gravel or broken stone. The road is usually built from 16 to 18 feet in width and from 6 to 8 inches in thickness, with expansion joints every 50 feet. The road should be built of carefully selected material. In foundations and building concrete structure is seldom tested to above 10 per cent of its actual strength. In road building, the strain will be near the maximum. Therefore, the material should be the best and carefully tested before being placed.

Cement roads are often reënforced with wire meshing, this being placed about midway between top and bottom. Reënforced concrete has given better satisfaction than that which has not been reënforced.

Concrete roads are well-adapted to automobile traffic and should be maintained with but little expense for upkeep. The life of the road is not well known, but it is probably from 30 to 50 years. Even after the surface begins to wear, a layer of asphaltic preparation placed over the concrete, as a base, will again make the road one of high standard.

Sand-clay roads are made by mixing these two types of soil. Sand roads are good only when wet; clay roads only when dry. A layer of sand hauled on a sticky clay road and worked into the surface will make a road which will be firm and hard the year around. This is known as a sand-clay road. A layer of clay worked into the surface of sand will make a firm road even when dry and this is known as a clay-sand road. These roads can be dragged and smoothed as the earth road. When sand or clay is not convenient the material must be carried. The expense is thus increased.

THE TELEPHONE

Not only does the telephone aid in the transaction of business, but it saves the farm home from isolation. With telephone and rural free mail delivery, any farm home is in touch with the best neighboring community, and good roads enable the family to take personal part in its social, educational, religious, and political life.

Mechanism of the Telephone. In construction, there are four essential parts to a telephone: (1) transmitter, (2) receiver, (3) wires, and (4) central station. Electricity is the means of transfer; the four parts are the tools by which it accomplishes this. The transmitter is a funnel-shaped mouthpiece, behind which a metallic membrane picks up the vibrations of sound and transmits them to the charged wire. At the other end, the receiver is a membrane that receives the vibrations from the wire and repeats them to the ear. The central station is simply an arrangement of some kind for connecting various lines of communication.

In some sparsely settled districts the central station is lacking, and a code of long, short, and repeated rings, enables a person to recognize his call. Electricity must of course be furnished by a power plant.

QUESTIONS

1. Give a brief history of roads.
2. Why are they important?
3. Wherein is energy expended in drawing loads?
4. How does the steepness of the grade affect the draft of a load?
5. Name and describe the kinds of roads.
6. Define: telephone, telegraph, transmission, receiver, central, and enunciation.
7. Describe the mechanism of a telephone.

EXERCISES AND PROJECTS

1. Secure or make a strong box three or four feet long by two or three feet wide and at least a foot deep. In the middle of the bottom, place six inches of ordinary soil. Slope this off until the slope just reaches the edges. Spread over the top of this about 3 inches of clay, over this about an inch of sand, and then about 2 inches of gravel as small as a walnut or smaller. A rounding slope of the surface should be maintained. Pound thoroughly—right thoroughly—and let dry. Tear away the box. You now have a small model of a reasonably good earth road.
2. If an old telephone is available, take it apart and examine. Observe the use and mechanism of each part, especially of the transmitter and receiver. Compare these with the human voice box and ear, respectively.

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CHAPTER LI

THE FARM COMMUNITY

According to the definition used by the United States Census Bureau in the last census, the term *rural community* includes those aggregations of people numbering 2,500 or less. This definition is arbitrary and not scientific, but it has the merit of being definite and as such can be effectively used in measuring rural depopulation.

Problems of Rural Communities. The rural problems discussed in this chapter are those which are primarily social in character. Most of them are connected in some way with one or more of the following: rural depopulation, rural health and sanitation, rural recreation, the rural school, and the rural church.

Rural Depopulation. The widespread movement of the people of the United States to the large centers of population has been one of the most important tendencies, from a sociological point of view, in modern times.

The extent of this movement is shown by comparing the percentage of increase of the population of the entire United States with that of the rural and urban population, respectively. The following table shows the relative increase for the last thirty years:

Table XIII.—Increase in Population in Percentage—General

	1910	1900	1890	Average
Total population.....	21.0	20.7	24.9	22.2
Urban "	34.8	35.5	53.7	42.7
Rural "	11.2	12.1	13.6	12.3

The average for the last three decades shows that the urban population has increased 3.47 times as fast as has the rural population.

For the United States as a whole, there has not been an absolute decrease in rural population, but in a few sections and in a number of states there has been an actual decline in the rural population during the last ten years. The New England States lost 5 per cent; the East Central States lost

Figure 192.—Home Economics Association.

2 per cent; New Hampshire, Vermont, Ohio, Indiana, Illinois, Iowa, and Missouri, lost in ratios varying from 7.2 per cent in Iowa to .5 per cent in Illinois.

The following tables show the facts with reference to the rural population in the State of Utah. These figures reflect conditions which may be regarded as fairly typical of the mountain states:

Table XIV.—Increase in Population in Percentage—Utah

Years	Population	Increase	Inc. in Urban	Inc. in Rural
1900-1910.....	373,351	34.9	59.9	18.9
1890-1900.....	276,749	31.3	40.0	27.0

Urban population increased a little more than three times as fast as rural during the last ten years.

The following table shows the percentage of the total population which is rural or urban:

Table XV.—Per Cent of Total Population—Utah

	1880-1890	1890-1900	1900-1910
Total Population of Utah...	100	100	100
Urban Population.....	35.7	38.1	46.3
Rural Population.....	64.3	61.9	53.7

Although the above shows the state to be largely rural, yet there is a substantial decline in the percentage of rural population during the last twenty years.

The tendency for cities to grow more rapidly than towns is strikingly shown, if we compare the rate of growth of the four largest cities of the state with that of the rural population. The last two censuses show the following:

Table XVI.—Comparative Urban Increase in Percentage—Utah

Years	State	Logan	Provo	Ogden	Salt Lake City
1890-1900....	31.3	19.4	9.9	9.6	19.4
1900-1910....	34.9	38.0	44.3	56.8	73.4

The rate of growth for the state as a whole increased only 3.6 per cent, but that for the cities increased more than 53 per cent.

Causes of Rural Migration. It is conservatively estimated that thirty per cent of increase in the city population of the United States has been due to the migration from the country to the city. There are two groups of causes for this migration. (1) Those primary forces which lie deep in civilization and are the fundamental causes of progress itself. We must expect that in the future, as in the past, young men and young women, born in the country with excellent vitality and possessing not only great capacity for work but ambition to succeed in the big things in the world, will continue to go where that work is—where life is complex. Any

attempt to stop this movement would result in failure and do more harm than good. (2) Other factors which may be called secondary lie in the relative merits and demerits of rural social institutions and conditions. Some of these which result in the city drift may be mentioned: failure of the farm community to supply necessary recreation and enjoyment, bad sanitary conditions, poor schools, and

Figure 193.—A farm community under irrigation canal.

inadequate churches. These conditions may be gradually improved, and, if they can be improved, there will no doubt be some check of the movement. It is significant that the tremendous city drift has gone on in spite of much back-to-the-farm preaching. Any plan of successful rural social improvement must aim to improve conditions for those on the farm rather than to check the movement from the farm.

Rural Recreation. An important function of play is the breaking down of prejudice and misunderstanding in society and the establishment of a basis for co-operation. Before co-operative enterprises can be made successful a "consciousness of kind" and the ability on the part of every member of the group to understand and sympathize with the interests of every other member are necessary. This

ability is conspicuously lacking among farmers. Farmers' Unions and other co-operative organizations have been rather unsuccessful—the farmer has been too individualistic. Play and recreation have not been important factors in his life and he is not in sympathy with attempts to supply these things for his children. But the demands of the young men

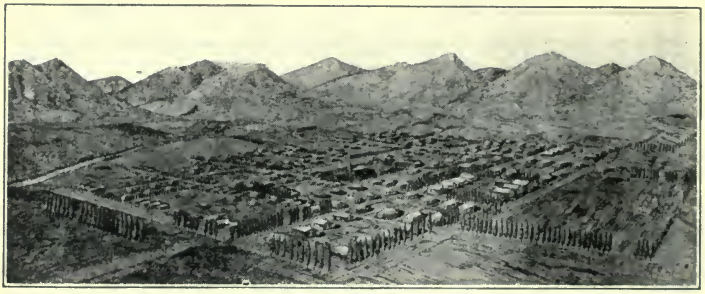

Figure 194.—Typical Utah village community.

and women are insistent; they must have recreation. They break away from the discipline of their parents and take the crude and unregulated recreation which the ordinary rural community affords or they migrate to the city where more opportunities for play and recreation are offered. The first choice means demoralization, loss of ambitions, and wasted life. The second choice means that the rural communities are to lose the best element in their population.

In all the age groups below twenty years, the rural population has the largest percentage, but in all the other groups up to sixty-five years and over the cities have the majority. This fact shows a decided tendency on the part of both young men and young women to seek the places of greater recreational advantage. If this tendency is to be counteracted at all, it must be done, not by trying to curtail play in our rural communities, but by organizing and controlling it. Play supervisors ought to be appointed. The farmers themselves must take a more genuine interest in the play

activities of their children. The difficulties in the way of making farm life attractive become greater when we get into grazing and dry-farm sections. Here the farm is large, the population scattered and practically no possibility of effective and satisfying social intercourse and recreation.

Rural Health and Sanitation. The unsanitary and unhealthful conditions which have prevailed in the past on the farms have no doubt had much to do with rural migration. The farm buildings have been poorly built and inadequately ventilated and the yards have been breeding grounds for disease germs and disease-carrying insects. The worst conditions have no doubt centered about the milk production and the water supply each of which has received attention elsewhere. Here the difficulty lies in the fact that public sentiment, strong enough to eradicate the unsanitary dairy equipment, cannot be developed and financial co-operation, sufficient to construct adequate water systems, cannot be secured. The problem is a social one and can be solved only when the population is large and compact enough to make community life and activity possible.

The Rural School. Another rural social institution which is responsible for the movement of some of the rural population to the city is the school. "Over 95 per cent of the social energy of the nation is directly devoted to matters of getting a living." About 50 per cent of rural school children never get beyond the seventh grade. Between 90 and 95 per cent of the population either remain in the community in which they are born and reared or go to communities whose interests and conditions are similar. The demands upon the rural elementary schools are, therefore, enormous, since they must give one half of the school population all the training it will ever get and must help 95 per cent of country people to understand the prevailing local conditions and agencies for the winning of their daily bread. That the country school is failing to meet these demands is too evident.

The following defects of rural schools may be mentioned:

(1) They are poorly supported financially. The country schools have sixty-seven of every hundred school children and receive only $33 out of every $100. The cost of teaching a city child averages $33 a year, whereas $13 a year is all that is spent on the average child in the country.

(2) The school houses are poorly built, have no satisfactory ventilation, and are wholly inadequate to be used as a social center. Moreover, they are not sufficiently equipped for the giving of vocational training which is needed so badly by farm children.

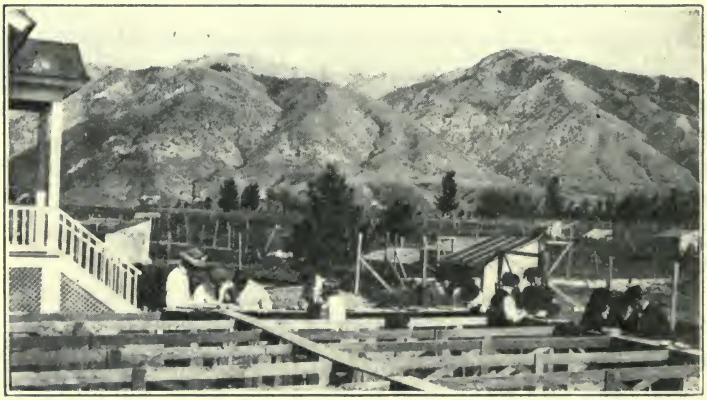

Figure 195.—Young farmers and college students studying breeds of swine; a method of community improvement.

(3) The schools are small and the school year short. In a majority of the states, between 45 and 60 per cent of the schools have fewer than ten pupils each. There is, therefore, a lack of stimulation to do effective work. When the school year is only six or seven months in length the pupils do not advance rapidly in comparison with the city child. Besides, short periods of employment do not offer enough encouragement for the teachers to equip themselves for the highest kind of service.

(4) The school curriculum is not adapted to the needs of farm life. The textbooks are stereotyped, designed to be hard rather than useful, and the material does not touch the lives of the pupils through their own experiences. The literature which is used is about city people and city conditions and the problems the pupils are asked to solve imply city life. The ideals held out are not drawn from the country and the heroes described are not farmers. These defects, however, are rapidly being remedied.

Much improvement can likely be made through the consolidation of rural schools. This would mean that the

Figure 196.—Farms in an irrigated district.

schools could be graded better, that larger numbers of pupils would work together, that better equipments could be had, and that the school year would be lengthened. Supervision could be more effective and the schools probably could be conducted more economically. Perhaps the most important advantage would be the establishment of a rural social center and the development of the right kind of leadership.

The Country Church. As nearly as can be judged from the few investigations, it seems safe to say that the vitality

and the power of the country church are declining. This is shown in a number of ways. (1) Church membership is increasing very slowly, and, in some sections, decreasing. (2) Expenditure for the support of the church and the payment of ministers, measured in terms of purchasing power, is on the decline. (3) Church attendance is decreasing. A study of the country church in two counties, one in New York State and one in Vermont, showed that church attendance has fallen off over 30 per cent in twenty years. (4) The training of the country minister seems to be inadequate to meet modern demands and he is failing to take the leadership he formerly did.

The causes for this decline group themselves about the facts that we have too many churches and that the people are losing confidence in the ability of those that we have, to help solve their problems. The church has had too much confidence in the finality of its own organization and has failed to adjust itself readily to changing conditions. One remedy seems to be in the socialization of the church. More time must be spent in studying the economic and social activities of the community and less time in poring over ancient literature in search for a defense of this or that ritual or point of doctrine. The ordinary person in our rural communities is beginning to see economic and social problems looming big on his horizon. He wants the church, as well as the other social institutions, to help him solve these problems; he has no interest in long ecclesiastical controversies.

The church, however, is based on a universal desire to worship, and its chief function is to provide a means for the expression of that desire. If it adequately performs that function it will be in the future, as it has been in the past, the most powerful social agency in our rural communities.

QUESTIONS

1. Why is a definition of a city based solely upon population, scientifically inadequate?

2. Can you suggest other causes, not given in this chapter, for the decrease in our rural population?
3. To what extent can the city drift be checked?
4. Why do farmers oppose Saturday-afternoon baseball games?
5. Would a law compelling farmers to observe a half holiday once a week be advisable?
6. What conditions surrounding the farm home make the life of a farmer's daughter uninviting?
7. Why has there been much opposition on the part of farmers to the establishment of consolidated rural school districts?
8. Why is it so difficult to get farmers to produce clean milk?
9. Should the school or the church be the social center?
10. Why do young people dislike to go to church?
11. Which is more important, the church or the principles for which the church stands?

EXERCISES AND PROJECTS

1. Make a map of your community, showing the location of homes, streets, parks, schools, churches, and any other public buildings. How might it have been made more convenient?
2. Why do the young people leave your community?
3. List the ways in which life in your community could be made more agreeable for boys and girls.

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CHAPTER LII

MARKETING FARM PRODUCTS

In the latter half of the eighteenth century several mechanical inventions were introduced in manufacturing, which revolutionized the industrial world. The spinning jenny, the power loom, and other power machines, completely upset the old methods of manufacturing and took from the farm home much of the work previously done there. According to the old methods, a small amount of capital was required in any manufacturing process; the new processes were to require extensive buildings, great investment of capital, and large bodies of laborers under a single head. In the early part of the nineteenth century steam was employed for purposes of power and also in transportation. In many cases steam or water power took the place of human labor, and, instead of doing many things, men came to confine themselves to one operation. Instead of one locality's having a highly diversified industry, it concerned itself with the production of one or, at most, a few products.

Specialization in Agriculture. In time, this influence became felt in agriculture. To-day we have the southern states producing cotton for the world; the middle states producing corn; the middle-western and northwestern states, wheat; California specializes in grains and fruits; and the New England and middle Atlantic states have become centers in manufacturing. The result is that the producer and the consumer of products have become widely separated, and the problem of transferring the finished article easily and cheaply from the final producer to the consumer has become a question of large proportions.

The Middleman. In an effort to bring about this exchange there has grown up a class of persons generally designated as middlemen. They undertake the task of purchasing the finished article from the producer and supplying it as needed to the consumer. This condition is general to all industries that manufacture for a widely distributed market. In manufacturing, the proprietor had so much capital involved that he had to devise cheap methods of distribution to send his products, at a reasonable price, to the great consuming public. Usually, being a well-trained business man, he did much to solve the problem for himself.

Marketing of Farm Crops. It was different with the farmers. Considered in the aggregate, they constitute the largest industrial and capitalistic class in the nation; but, when considered severally, the units are small and widely separated. Besides, farmers work alone and in contact with nature and are strongly individualistic. Co-operative effort is, therefore, difficult. The result has been that they have competed intensely among themselves, having, as a consequence, received very low returns on their labor.

The low prices paid to the farmer have not always meant cheap goods for the consumer. In too many cases a large number of middlemen have come between the farmer and the people who consume his products. These middlemen as a class, for the service rendered to society, have undoubtedly received too large a share of the total output. It has been estimated by the Secretary of Agriculture, that, on an average, for every dollar the consumer pays for farm products, the farmer receives only fifty cents. The balance goes to the middlemen.

Co-operative Marketing. The leading farmers of the country have been thinking about this situation and have reached the conclusion that 50 per cent is too large a proportion to pay for the service rendered. In order to eliminate, as far as possible, this burdensome charge on their

industry they have, in a great many cases, organized co-operative marketing associations so as to do their own marketing. In raising staple crops where the market prices are fairly standard for the whole country, the profits obtained are the results of cheap, economic, and efficient means of production; on the other hand, in specialized farming, very much more depends upon an efficient system of marketing.

In the case of wheat, oats, corn, rye, etc., there are usually standard prices for the whole nation; but with such specialities as oranges, peaches, eggs, and strawberries, almost everything depends upon getting the products to the consumer in prime condition and at a price so low as to give a wide market and yet net the producers a fair return. It is not to be implied, that co-operative organization is not desirable for standard crops, but that it is not so essential for success.

Farmers' Associations. Co-operative farmers' associations have met their greatest success in specialized farming and institutions closely allied therewith such as fruit-growing and marketing, cow-testing, cow, horse and corn-breeding, grain elevators, creameries, meat-packing, egg-selling, irrigation canals, telephone and insurance companies, credit associations, and many other industries. In fact, many of these associations have been eminently successful, e. g., California Fruit Growers' Exchange, Hood River Apple Growers' Association, Rocky Ford Melon Growers' Association, and others too numerous to mention. A co-operative association may be organized under the laws of the state; yet it differs from an ordinary capitalistic corporation. In the ordinary corporation the primary purpose is to make dividends on the capital invested; but the primary purpose of co-operative marketing is to better the economic conditions of its members by securing better prices for the products of the farm. For this reason, the membership, as far as possible, should be confined to actual farmers, who should take

precautions not to permit the control to pass into the hands of a nonagricultural class.

Farmers' co-operative associations are usually organized under the corporation laws of the state. Unfortunately these laws are not well suited to meet the needs of these associations. They were enacted primarily to meet the needs of stock corporations.

Organization. The organization must concern itself with local affairs and must also market the products, which generally involve a wide area. To meet these two conditions it is desirable to have two organizations closely federated. The local organization concerns itself with packing, spraying, inspection, and with the purchase and control of such machinery as may be used locally in common. To establish a proper system of effective marketing is generally too expensive for a local unit. It would frequently eat up the entire crop in expenses. To handle this problem a federated system uniting the local units and covering a large area has proved very efficient. By dividing the expense among a large number of local units the quantity of products to be sold becomes so great that the burden of expense for any unit is correspondingly small. Moreover, the total income is sufficiently large to secure the services of competent and efficient employes. In case of the citrus fruits of California local organizations were formed, which have been federated into districts, and the districts into a state-wide association known as the California Fruit Growers' Exchange. The local organizations oversee the packing of the fruit, own and operate much machinery in common, and own and erect packing and storage houses. The districts forward the daily price quotations, secure cars, and arrange for the loading and shipping of the cars from the various localities. The Exchange advertises the fruit all over the world, secures a market for it, and supplies the various districts with daily price quotations. In this way the expense is localized where

it pertains to local operations alone, and is state-wide where it pertains to the whole industry. Its chief advantage is that it so distributes the financial burden that it is light on all.

The Board of Directors will naturally be selected by the members. The number on the Board should be large enough to be fairly representative of the members of the association; but on the other hand it should not be too large, as it then becomes so cumbersome and expensive that it is inoperative. This result frequently happens when the organization is made up of several geographical units, each of which insists on representation. The Board, therefore, becomes inactive and the control passes over entirely into the hands of the manager. The duty of the Board of Directors is not to manage the association, but to elect a manager to oversee the organization; to satisfy themselves that its affairs are honestly and consistently managed, and to offer suggestions to the manager, which, if serviceable, he is to carry out.

Stock-holding. Probably the best thing, as the laws now stand, is to organize a corporation. In the organization of a corporation, however, several precautions should be taken. The amount of stock that any one member may secure should be strictly limited; likewise the maximum number of votes that any stockholder may cast. If this limitation is not observed, the organization is, in the course of time, likely to pass into the control of a few farmers. It is also advisable to fix a maximum rate of dividend to be paid on the stock, which removes the motive to become large stockholders. In general, the dividends should not exceed the normal rate of interest. If the earnings exceed this amount they should be divided among the members according to the amount of business transacted. When stockholders offer their stock for sale, the articles should provide that the society shall have the first right of purchase. If such regulations are not provided, the association, if successful, will pass under the control of a few men; new farmers will

not be admitted, and it will be conducted as an ordinary dividend earning corporation. In fact, many associations, organized without capital and on a nondividend paying basis, have proved eminently successful, the expenses being met by an assessment according to acreage or according to the amount of business done.

Obligation of Growers. Whatever scheme is followed, the farmers must be obligated in some way to support the association financially, either by the purchase of stock or by a contract. Powell, in his work on "Co-operation in Agriculture," says, "The membership agreement is the foundation stone on which the stability of a farmers' co-operative business association is reared." Experience has shown that an association dependent upon its members' honor for support will fail. If higher prices are offered, the farmers will leave and sell elsewhere. The result is that the association fails unless it has provided against such a contingency, and, when it does fail, prices fall to their former level. The farmer must enter into an agreement which provides that, in case he exercises his right to sell elsewhere, he will pay the association a certain percentage of the sale price to help defray its expenses.

The Manager. The board of directors should elect as manager a capable business man who understands the business at hand. Then he should be given sufficient authority to do the business. To get such a man, the organization must pay him well. To place the work in the hands of an untrained and inexperienced man spells failure. Too often the mistaken policy is pursued of selecting an incapable manager because he is cheap. A competent man will demand at least as much pay as he can get from a private employer; no other man can succeed.

Finally, the association must avoid the introduction of partisan politics. They have always disrupted the commercial organizations they have entered. Each association

should remain strictly a business enterprise and conduct itself as such.

QUESTIONS

1. Why has a change in factory processes affected marketing?
2. In what ways has agriculture become specialized? Does this affect marketing problems? In what way?
3. Why do farmers have trouble about marketing their products?
4. How is co-operative marketing conducted?
5. Name and describe some farmers' associations.
6. How are they organized?
7. What do they buy and sell?
8. What are the obligations of the farmers to such an organization?
9. How is the manager chosen?
10. Should there be such an organization in your neighborhood?

EXERCISES AND PROJECTS

1. Debate the question:
   Resolved, That there should be a farmers' co-operative organization in this vicinity.

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CHAPTER LIII

THE FARM HOME

The underlying principle which should guide all the relations of the farm home is simplicity. Simplicity in the home is not an indication of inferiority or of decadence, but is the vital characteristic of all that is best in human existence.

One of the grave evils of life everywhere has been the tendency of persons to assume to have more than they really possess, and to appear to be what they are not. Sham of any kind is demoralizing. It is a sort of dishonesty that will corrode the whole being, making the life unsatisfactory. The family should have what it can afford, but no more, of food, clothing, furniture, amusements, and luxuries. If the grounds surrounding the house are laid out carelessly or with great elaboration without regard to use; if the house is badly designed; if there is a great deal of unnecessary ornamentation and lack of harmony—wherever these conditions prevail, there will be a tendency to buy cheap, showy things, all of which react on the dwellers to make them careless and unreal.

Home Furniture. Home furnishings need be neither elaborate nor expensive. Let the family buy what it needs, start with a few simple articles of furniture, and add new ones as it is able; but let all be of some uniform design and free from unnecessary ornamentation.

Home Art. All about the house, its architecture, building material, and paint, the wall colors, carpets, and rugs should so blend as to make, with the lives of those who dwell there, a simple, harmonious unit. At first, little that is purely decorative need be bought; but that little should be selected with care, as it is distinctive of one's taste.

In the reproductions of great works of art—pictures, sculpture, and vases—a person may get a great deal of that inspiration given by the originals, and learn to love the better things created by master minds. Often a cheap thing appeals at first; but a careful study proves that its qualities which are

Figure 197.—A convenient kitchen cabinet. Note the swivel bins and sliding panel.

only on the surface, are seen at once and are a disappointment to those who look deeper. A few good pictures and a few choice articles of bric-a-brac setting off the walls, artistic in plain coloring, will make any home a place of rest and comfort as well as a place in which to live.

Home Reading. A family that does not read, or that is not provided with good books, is unfortunate. The works of many of the great writers are published at prices anyone can afford; the cost of newspapers and magazines is reasonable. There is no need of not knowing what to buy. The librarians of our large schools will gladly furnish lists of suitable books and publications.

Newspapers should not be given too much prominence.

Although we owe much to the newspaper, much that is not necessary is printed, and reading it wastes time. The great events of the day, no matter in what part of the world, are generally treated on the first page and should be noted. Often a headline will give all a person needs to know, especially if it deals with a scandal or a crime or with a subject in which he is not concerned.

Magazines have one page for the men on politics and science, one for the women on home and fashion, one for the children on subjects they like, and, in addition, the general reading. One or more good agricultural papers, one of which deals largely in your specialty, dairying, horses, hogs, fruit, or sugar beets, is likely to help much. The bulletins from your Experiment Station and from the Department of Agriculture at Washington may be had on request.

As soon as children can understand words, the simple nursery tales and fairy stories should be told or read to them. As soon as they can understand, the parents can with profit read them stories of adventure, of lives of worthy men of history, and of the myths of the Greeks, the Romans, the Germans, and the Scandinavians. Then let them read wholesome stories for themselves. With fiction of the better class, biography, history, and travel, and the practical work in which all are interested, there need be no unoccupied time; young and old will gradually acquire a fund of general information that will be wonderfully helpful.

All members of the household should learn that books are sacred things, representing not the money put into them, but the thought of the author. Regarded in this way, books will be handled with respect. Acquaintance with them will have much the same influence that contact with cultured people has. Literature, approached and appreciated in spirit, will be a constant source of pleasurable and profitable information—of culture unsurpassed. The Bible, particularly, is worthy of continued attention.

Home Food. So far as possible the farm should produce its own food stuffs. There is no economy in selling to the butcher, at a comparatively low price, calves, hogs, and sheep on foot, and then buying them back at high retail prices.

Every farm should have an ice house with a cool room to preserve the meat in warm weather. A room six feet square or six by eight feet would answer. When not used for meat, such a room would be handy for eggs, butter, milk, or cream, and for perishable fruits or vegetables.

Vegetables may be had at all seasons; more peas and beans should be used to take the place of meat at times. The vegetable cellar each fall should have a supply of beets, carrots, cabbage, and celery, in addition to a stock of potatoes, apples, and bottled fruit. The storeroom should have supplies of dried corn, beans, and peas, besides a quantity of cheese. With such supplies, in addition to milk, cream, butter, and eggs, the farm home need not envy the palace, as it affords all the table luxuries that are necessary for good living.

Cost of Foods. Though the kind, variety, and cost of food must necessarily be regulated by the size of the income, farm folk need not depend very much upon commercially canned and commercially bottled goods. The real delicacies and luxuries of the table may be provided on the farm, at low cost, and with positive pleasure and physical profit.

Home Amusements. To attempt to get much enjoyment from attending trifling parties, picture shows, etc., that are now so common is not desirable. Life demands something of variety, and provision for it is proper, but excess amusement readily becomes a kind of intoxication.

On account of the comparative isolation of farm houses, it is desirable that as much amusement as possible be provided in the house where there are several boys or girls. Good nature and perhaps something of burlesque or mimicry will tend to remove part of the irksomeness of the difficult

and tedious tasks. Let music be encouraged, and games, such as checkers, chess, dominoes, and some of the new card games, with an occasional party. In fine weather, croquet, tennis, ball, swinging, etc., may be adopted for outdoor play to good advantage. These, with driving, horseback riding, and walking, should give sufficient variety to satisfy any one. Care should be taken not to make pleasure the principal end, and not to cause some of the family to have all the drudgery.

Health. There is little doubt that a great proportion of physical ills comes from careless or immoderate eating. More persons die of overeating than from starvation. Persons who work out of doors, as most farmers do, can assimilate much larger quantities of food than those who are confined indoors. Some growing children and persons recovering from wasting diseases seem almost unable to get enough; but everywhere and to all there is a danger line beyond which ill health is the penalty.

There may be times, when, for a short period, overworking seems positively necessary, as in case of sickness, accident, and the rush of seeding or harvesting. At such times good sense directs that all do their utmost; but later they should take time to recuperate. Sufficient sleep is essential—primal —to health.

Overwork, overeating, and excessive pleasure-seeking are forms of moral degeneracy, which are sapping away the best in many lives. The physical basis of health, and its greatest secret, is moderation.

Adjustment to Duties. The farm home should be a place of faith in one another and of helpfulness. A really successful home is a kind of partnership in which father and mother are the senior and most responsible members. They must have *their* work and must do it; the children must have *their* work and must do it. None should overwork, but none may shirk proper responsibility and toil.

As soon as is consistent with their development, children should be required to help in some simple way; other tasks should be added later. The greatest boon conferred upon people is *work*, and there is no injustice in requiring that all do their proper share in the necessary labor. To work and to learn that there are trials to bear, is not only a privilege, but it is a right that all are entitled to enjoy.

Since there is not a proper balance in some homes in number of boys and girls, the boys ought to learn to cook, sweep, wash dishes, and scrub floors; or the girls to milk, tend the garden, or help otherwise outdoors. When such changes are necessary or advisable, if the young people will think of their common dependence upon the different operations, there need be no seeming loss of dignity. Any man or boy, young or old, who will not help the women when their work is pressing or severe, has no proper conception of what dignity may follow; and women and girls who say, "That is a man's work, and I will not do it," have yet to learn that ideal womanhood is based upon a willingness to help in the necessary work of life whether directly in accordance with their own duties or with something else just as necessary. With such a conception of the home duties and willingness to do even more than one's own part, the home becomes a place of joy and satisfaction.

Home Finances. A very vital matter that must be learned early is living within the income. Sometimes husband and wife have no idea of limiting their wants, and so live too fast financially; but more commonly these two struggle along, get ahead so as to be comfortably well-to-do, and then, as the children learn how money may be used, they squander more in a month than the parents saved in years. Such extravagance is not justifiable on any ground. Each member of the family should have first what is needed—afterwards, what is desirable. On the other hand extreme stinginess is both unlikable and unprofiitable.

Such things as household furnishings, vehicles, and live stock must be regarded as for the common good. All should use wisdom in caring for the common property, in avoiding selfishness, and in causing unnecessary work for the others. A boy returning with a horse and buggy, has no right to leave the vehicle out in a storm, throw the harness down and only half care for the horse. In the house and out each should take care of what especially concerns himself and thus retain his own self-respect and avoid imposition on others.

Home Rights. In all their association all members of the home should maintain courtesy one to another. Proper criticism should be accepted as a help, but the spirit of faultfinding must not be encouraged or tolerated; nor should a feeling of superiority be allowed. Humility, good will, industry, faith in man and in all other good agencies, trust in God, regard for the wishes and welfare of others, a desire to know that is satisfied by intelligent consideration of the great questions of the day and of the necessities of their general occupations—these will create the best conditions for happiness.

QUESTIONS

1. Define with respect to home life: home, house, life, luxury, necessity, amusement, work, play, food, clothing, convenience, neat, attractive, gaudy, magnificent, sincerity, sham, harmonious.
2. Discuss briefly home art.
3. Why should the home be simple?
4. How much reading should be done in the home? Discuss the kind of reading adapted to the home.
5. Name good and poor foods for the farm home. The city home. The village home.
6. What is the place of home amusements?
7. Give several health precautions.
8. How should the financial problems of a home be handled?
9. What should be the part of praise, blame, and help between members of a family?
10. Why should work and play be planned ahead?

EXERCISES AND PROJECTS

1. Let each student plan the time and place of his chores, school, and amusement for a week.
2. Make a list of inexpensive improvements that would make your home, school, and office or library more attractive.
3. Make some of these improvements.
4. Write out the ten commandments for a happy and efficient home life.

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